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SCIENCE COMMUNICATION WITH ALMA:

#WAWUA AND THE ROLE OF ANIMATION VIDEO IN SCIENCE OUTREACH

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For mom and dad,

I owe them everything.

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ABSTRACT

KEYWORDS: Audiovisual Science Communication, Animation video, Science Outreach, Science and Social Media, Astronomy and Astrophysics Outreach, #WAWUA

With the rise of web 2.0. and the current social media landscape, audiovisual content, and online video in particular, provide a novel and interactive platform for communicating science. This report focuses and reflects on three, interrelated subjects: (1) The potential animation videos offer to science outreach, especially to astronomy outreach, with the singular challenges and benefits it faces. Animation allows the representation of un-filmable or abstract scientific processes, offers the possibility for narrative integration and visual storytelling, and has an intrinsically artistry and versatile nature. All these characteristics make it an invaluable tool to reach and engage audiences with a wide range of backgrounds, despite the inherent complexity and technicality of science subjects; (2) The step-by-step process of producing animated videos – which include background research, script writing, storyboarding, voice over and its editing, illustrating/designing, animating and sound editing – and how they were used to create #WAWAU: "Why do Astronomers Want to Use ALMA?". #WAWUA is a series of five two-minute animated videos and the result of a 9-month internship in the Atacama Large Millimeter/Submillimeter Array's (ALMA) Education and Public Outreach Office (EPO). The project aim is to communicate the science behind ALMA and the radio telescope itself in a simple, accurate and engaging manner; (3) The reception of the animated series in ALMA's social media and how the monitoring of that performance allows for both the measuring of #WAWUA's impact in the audience and the development of guidelines based on the lessons learnt throughout the entire production process, from the project's conception to its evaluation.

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LIST OF ABBREVIATIONS AND ACRONYMS

ALMA	Atacama Large Millimeter/Submillimeter Array
AOS	Array Operation Site
EPO	Education and Public Outreach Office
ESO	European Southern Observatory
FCSH-UNL	Faculdade de Ciências Sociais e Humanas – Universidade Nova de Lisboa
ITQB	Instituto de Tecnologia Química e Biológica
JAO	Joint ALMA Observatory
LSA	Large Southern Array
LMA	Large Millimeter Array
MMA	Millimeter Array
NAOJ	National Astronomical Observatory of Japan
NRAO	National Radio Astronomy Observatory
SCO	Santiago Central Office
OSF	ALMA Operations Support Facility
#WAWUA	"Why do Astronomers Want to Use Alma?"

INTRODUCTION

This report is a result of the work developed during the 9-month internship at the Education and Public Outreach Office (EPO) of ALMA, the Atacama Large Millimeter/Submillimeter Array, carried as part of the Science Communication Master's degree program headed by the Faculty of Social Sciences and Humanities of Universidade Nova de Lisboa (FCSH-UNL) and the Instituto de Tecnologia Química e Biológica (ITQB).

The internship had an original intend duration of 6 months, to be fulfilled between the 14th of October 2016 and the 13rd of April 2017. However, this period was extended for 3 additional months, until the 23rd of June 2017. Throughout this period there was an opportunity to contribute to some of the communication efforts and outreach activities of the EPO in Chile: from ALMA open day and "Noches Bajo las Estrellas" (an outreach activity direct towards the general public, which joins talks by ALMA staff with sky observations) to the development of written and multimedia content for ALMA's online presence, both on their website and their social media channels.

Nevertheless, the main focus of the internship was the creation and development of a series of short animated videos – later called #WAWUA "Why do Astronomers Want to Use ALMA" – from the first steps of imagining the best format for the series, its number of episodes, the audience it would be directed towards, etc. to the final post-production details. #WAWUA was entirely produced during the internship and later published through a variety of channels with a special focus on social media. The current report delves into this project and is divided into five different parts.

Part I is an effort to show the relevance of animation videos as a channel to communicate science in the current internet and social media landscape. It gathers examples of the use of this particular type of videos today and lists a series of guidelines and best practices in the field.

Part II introduces ALMA. It explores the history of its creation, the organization and cooperation behind the biggest ground-based telescope to date, its main scientific goals, and the hopes behind such a sensitive and precise radio telescope. Additionally, it delves on the potentials and challenges of ALMA's Education and Public Outreach Office (EPO), as well as their strategy to communicate astronomy, radio astronomy and the observatory itself.

Part III focuses on the relation between part I and part II, i.e., it highlights the evidences supporting the use of animation videos as a solution to heighten the potentials and face the challenges of ALMA's, radio astronomy's and astronomy's communication. Furthermore, part III reveals the reasoning behind the creation of #WAWUA ("Why do Astronomers Want to Use ALMA?": its goals, audiences, and messages – and encompasses a step-by-step guide to the processes used to produce the series.

Despite the fact that the videos were only published after the conclusion of the internship period, Part IV focuses on their reception in social media, particularly Facebook. It includes a brief description of the different platforms used to disseminate the videos and an analysis of different parameters measuring the videos' impact in ALMA's two Facebook pages (Spanish and English version).

Finally, part V, gathers the main lessons learnt by (1) working at ALMA, (2) going through the producing process, and (3) evaluating the performance of the videos in social media. This work was done with the hope that the assimilated lessons would promote changes to benefit ALMA's outreach in the future.

PART I

ANIMATION VIDEOS: A POWERFUL TOOL FOR SCIENCE COMMUNICATION

This first part is an effort to answer the question: **"Why using animation videos to communicate science?"**. It explores the importance of visuals, in particular, video and animation video, as channels to communicate science in modern society. It aims at demonstrating the relevance of this audiovisual media as a powerful tool for science outreach through the internet and social media. It gathers, as well, some relevant examples of the use of animation videos for science communication today, in an effort to draw out some of the best practices in the field.

Clarification of terms

The meanings and definitions of terms like 'science communication', 'science outreach' and others that relate to the interactions between science and the public, often lack clarity (Burns et al., 2003). For the purposes of this report, any mentions to 'science communication' or 'communicating science' are assumed to relate to the broad definition of the term given by Burns et al. (2003): "Science communication is the use of appropriate skills, media, activities, and dialogue to produce one or more of the following personal responses to science: awareness, enjoyment, interest, opinions and understanding.".

This way, science communication will be used as an umbrella term encompassing the idea of *science outreach* which will, throughout this report, refer to "any scientific communication that [directly] engages an audience outside of academia" (Poliakoff and Webb 2007, as mentioned by Varner, 2014)

I.1. VIDEO AND THE POWER OF VISUAL SCIENCE COMMUNICATION

"*Historically, images have always been part of science." - Trumbo, 2000*

Scientific concepts and information about science reach the public through a variety of channels. From formal curricular education to digital media; from institutional outreach activities to the arts (Berlin, 2016). Across all those different channels, visual communication has always played an essential role (Trumbo, 2000; Rigutto, 2017).

Many scientific concepts are beyond the realm of human vision. They are often (a) too small for the naked eye to see, like the infinitely small quantum mechanics; (b) too far away or unreachable, such as the far reaches of space or the depths of the ocean; (c) too complex or abstract to be communicated using only words (Kent 2015 and Evagorou et al. 2015). Visual representations (i.e. Illustrations, diagrams, tables, models, videos) are therefore not only fundamental for scientists to interact with their science (Richards 2003) but also especially important for the communication of these concepts, which are otherwise hard to grasp and comprehend, to the public (Lynch 2006 as cited by Evagorou et al. 2015).

Video in particular, has been pinpointed as valuable tool to establish and reinforce the bridge between science and the public (May et al., 2011; Kent, 2015; Scholl et al., 2016). It takes advantage of both (a) the intrinsically visual nature of science and (b) the stimuli unavailable in either written communication or static visual content, like sound and motion (Scholl et al. 2016; Bohlin et al. 2017, Mar et al., 2016). Video helps "conceive events and processes that are difficult to grasp because they span temporal and spatial scales far larger or smaller than those that we can directly perceive." (Bohlin et al. 2017) providing the viewer with new perspectives.

Additionally, it has been shown that videos not only have the capacity to explain complicated concepts but also raise awareness on those topics and influence people's decisions (Lie & Mandler, 2009 as cited in Bello-Bravo et al., 2015). This way, video has a distinct strength to both engage audiences and promote the 5 key personal responses to science that Burns et al. (2003) defines as the purpose of science communication:

"Awareness, including familiarity with new aspects of science; Enjoyment or other affective responses, e.g. appreciating science as entertainment or art; Interest, as evidenced by voluntary involvement with science or its communication; Opinions, the

forming, reforming, or confirming of science-related attitudes; Understanding of science, its content, processes, and social factors"

Videos has, therefore, become a crucial channel in the spreading of scientific ideas and popularization of science in the last century (Kent, 2015).

I.2. ANIMATION VIDEO: A STEP FORWARD IN COMMUNICATING SCIENCE

"*You can let your imagination go wild in an animated film. The laws of physics can be suspended. Time can be compressed or expanded. The action can take place on Earth, on a distant planet in the Andromeda galaxy, or in an imaginary world populated by talking tomatoes. (...) The possibilities are endless." - Karen McKee, Ph.D*

Animation is a complex term that can be hard to define. Zaman et al. (2011) described animations as "depictions that change continuously over time and represent a continuous flow of motion". This broad definition, lends itself to a wide range of applications, from traditional animation and 2D vector-based animation to motion graphics.

In all its different forms, animation video represents an incredible tool to communicate science (Kim et al. 2006; Kent, 2015; Berney and Bétrancourt, 2016; Scholl et al. 2016). It offers the possibility to combine both: (a) the methodical and strategic approaches necessary to convey complex and heavily technical scientific ideas in a quick and simple manner and (b) the creativity necessary to make those ideas engaging and compelling (Kent, 2015).

As Kent described in 2015, animation videos have "the potential to thrive as deliverers of complex and heavily scientific information in clean, digestible ways" making them an important tool to reach broad audiences, including those with limited literacy and short attention spans.

In recent years, research that pinpoints the power of animation for communicating science has been growing (Kim et al. 2006; Bello-Bravo et al., 2011; Bello-Bravo et al. 2015; Kent, 2015; Berney and Bétrancourt, 2016; Scholl et al. 2016; Fisk, 2008). Recommendations for the use of this audiovisual medium focus on several of its advantages:

1. **Animation videos allow the representation of un-filmable or abstract scientific processes (Kent, 2015 and Scholl et al., 2016)**.

   Animation has fewer limitations than live action video and can be an especially good option when this kind of video is difficult or impossible to film. Unlike live action that is limited by external influences like location, weather, the laws of physics, etc., animations grant their creator(s) the possibility of making the invisible, visible; the far away or unreachable, close, and familiar; the complex and abstract, simple, and concrete. As Kent (2015) refers, when mentioning the work of DelGaudio (1995): "animation can portray "undocumentable" events, because a camera has not been present at an event or the event happened prior to the camera's invention".

   Berney and Bétrancourt (2016) pinpoint animation video as especially relevant to show spatial and temporal relationships. Using animation to illustrate the different stages in the development of a galaxy, for example, allows the filmmaker to portray an astronomical process that is extremely slow and impossible to film, making the entire process easier to visualize by the viewer.

   Animation videos are, therefore, a valuable tool to describe all kinds of dynamic systems in science, such as natural phenomena, biological processes, mechanical devices, or the evolution of systems. Additionally, they give the viewer something concrete – a new visual perspective – to represent potentially abstract concepts (Scholl et al. 2016), pushing away from the language frame of mind and minimizing the disadvantageous effects of the often technical and field-specific vocabulary used to convey these ideas.

2. **Animation can communicate ideas in a way that is not only appealing visually but also has the power to generate emotions in the audience (Scholl et al, 2016; Kim et al. 2006; Bello-Bravo et al., 2011).**

   Animated videos are not only (1) channels for communication that appeals simultaneously to both visual and auditory senses. Which has been shown to be important for knowledge acquaintance, as people learn better from the combined use of words and pictures than from words alone (Mayer 2001; Fletcher and Tobias 2005 as cited by Bohlin et al. 2017; Cruse 20??): "people will generally remember: 10% of what they read, 20% of what they hear, 30% of what they see, 50% of what they hear and see" (pp. 7-8, Wiman and Mierhenry, 1969 as cited by Marshall, 2002). But they also (2) have the potential for great artistry and entertainment (Kim et al., 2006 and Scholl et al., 2016). As Martinez-Conde and Macknik (2017) observe:

"cognitive science research indicates that nonnative languages evoke weaker emotions in bilingual listeners than equivalent words in one's mother tongue. When a major scientific discovery generates little public interest, there is a similar disconnect between content and emotional impact. To bridge the gap, we must decode science to a narrative that generates feeling."

Animation video provides that opportunity to integrate a narrative, becoming a tool for visual storytelling, and providing an impactful and humanized way of communicating science to a wide audience of both scientists and non-scientists (Pereira, 2005; Mayne, 1993 as cited by Bello-Bravo et al., 2011; Martinez-Conde and Macknik, 2017).

"*As long as there have been people, there have been stories - ancient cave paintings, stories we tell children, stories in songs and pictures, plays and films, history and politics, and of course the news. They are in every culture and are very powerful. They teach us so much and engage listeners strongly."* (Aravopoulou et al., 2017).

Research shows that the human brain responds in a special way to stories, anecdotes, and narratives (Ciotti 2017; Green and Brock 2000; Zak 2014; Widrich 2012 as cited by Aravopoulou et al., 2017). Stories are more likely to evoke emotion, interest, and understanding than traditional logical-scientific communication (Dahlstrom, 2014; Berlin, 2016). They persuade, amuse, and create engagement even in complex situations (Stone et al., 2015 as cited by Aravopoulou et al., 2017).

Therefore, the power of animated videos in science communication lies precisely in their ability to communicate with the viewers on both a cognitive and emotional level, engaging and motivating the audience and effectively delivering the desired message (Bello-Bravo et al., 2011; Berlin, 2016 and Cruse, 2006).

3. **The production of animated videos often brings together artists and scientists for interdisciplinary collaborations (Scholl et al. 2016; Ebert and Bailey, 1999).**

   When it comes to the benefits of art-science collaborations, often the first topic mentioned as a representation of the success of this interaction is the connection between science and the public those collaborations generate (Webster, 2005; Curtis et al., 2012). Artists are able to communicate with a large audience and are experts at exhibiting their work in public, many scientists however, struggle to accomplish the same levels of public exposure (Webster, 2005; Moser and Dilling, 2007, Cribb and Sari, 2010 as cited by Curtis et al., 2012). Several studies have shown (e.g., Curtis et al., 2012; Lovett, 2004; Nadkarni, 2004) that the interdisciplinary collaborations between the two are mutually beneficial – "The scientist benefits from intuitive thinking, the artist from linear thinking" (Samsel, 2013) – and often resulted in improved and enriched communication of science to the public (Scholl et al. 2016; Webster, 2005).

   According to Curtis et al. (2012) some of the benefits of this symbiosis between science and the arts come from (1) the capacity of arts to synthesize, simplify, and convey complex scientific ideas in a way that makes the information both more interesting and easier to remember; (2) the way the interactions between artists and scientists promote, in the latest, a new way of looking at scientific problems and their transmission to an audience, generating a better understanding of what takes to communicate a certain scientific idea to non-expert audience; (3) the fact that just like by using storytelling, often the results of bringing together artists and scientist is a compilation of stories that resonate with the audience on an emotional as well as intellectual level, promoting engagement (Samsel, 2013).

4. **Animation is inter-institutional and international (Bello-Bravo et al., 2011).**

   As written by Lee (2015) animation is a pioneer in generating global flows of both production and consumption. In science communication, it opens a window for endless opportunities in both ends of the link: the science and the public.

   On one end, in the academic and scientific production and communication end of the link, animation videos are a powerful tool because they are not limited by a geographical location unlike many live-action productions (Bello-Bravo et al., 2011). Not only they can, and are, normally produced and developed by a network of individuals from multidisciplinary backgrounds (scientists, designers, animator, science communicators), but also by individuals that can be located in all different regions around the world. This represents a major advantage in a world where science and scientific knowledge is often the result of consortia work - an effort of individuals not only belonging to different institutions but also, in many occasions, different countries (e.g.: Kroto, 2001; Collins et al., 2003).

When it comes to the audience and the public end of the link, animation is an asset because (1) voice overlays in a diversity of languages can be easily added, without having the uncomfortable unmatched sound and mouth movements that happen in dubbed live action videos. What facilitates the spreading and sharing of scientific ideas across different language groups in a way that wouldn't be possible using one single language (Martinez-Conde and Macknik 2017; Bello-Bravo et al., 2011); (2) "its simple, culturally neutral style means that it's attractive to all audiences, no matter where in the world they're watching." (Bello-Bravo et al., 2011).

5. **Animation is versatile and can be used to communicate science in many different places and situations (Kent, 2015; Scholl et al. 2016).**

Animations give institutes, researchers, science communicators, among others, an engaging product that can be used in several different situations and places: websites, social media, public events, museums, science center expositions, etc. (Kent, 2015). They can as easily be used to be a social media campaign on Facebook or as lead-ins to develop teaching resources for teachers to use. (e.g., Cheng et al., 2008; Smith, 2009 as cited in Scholl et al., 2016; Fisk, 2008).

Animations can be paired with existing outreach or easily incorporated in citizen science projects as a way to introduce the audience to a project overview or clarification of important concepts (Scholl et al., 2016). They are a hugely versatile way of inspiring people and encourage them to explore further (Kent, 2015).

I.3. WEB 2.0: AN IDEAL PLATFORM FOR VIDEO IN SCIENCE COMMUNICATION

"The new media environment is changing how science is communicated to nonexperts. New media audiences are imbued with greater power to seek, select, and share the information that interests them the most." - Dahlstrom, 2014

Paradigms concerning science communication have gradually shifted over time. From the dominance of the 'deficit' model, which attributes the public's disengagement, skepticism or hostility towards science to its lack of scientific knowledge and therefore, advocates for a communication *from* scientists *to the* audience (as passive recipient) as the way to contradict the negative positions (Gross, 1994 as cited by Bultitude,2011); to the increased importance of the 'dialogue' approach, in which the two-way exchange of information between scientists and the public is deemed essential to promote a change of attitude in the public towards science (Bultitude,2011; Hetland, 2014).

Similarly, for little over a decade the internet has gone through a major change – from its original environment where audiences were passive recipients of information to a new one where participation is key, and anyone can interactively, dynamically, and collaboratively create and disseminate content (e.g: Kent, 2005; Peters, 2010; Babu and Gopalaswamy, 2011).

With the establishment of this new era of the internet – Web 2.0 (2004 – Present) – and the use of formats specially directed to participation and interaction – social media – a new tool that has become available for all those seeking to communicate science to the public. One that not only brings the scientific content to the public rather than requiring the public to seek it a fixed location (West, 2005), but also incentives and facilitates 'dialogue', allowing the audience to contribute with, not just passively receive, content (e.g: Dudo, 2015; Nisbet & Scheufele, 2009; Uren & Dadzie, 2015 as cited by Rosenthal, 2017; Kent, 2015).

Social Media which includes blogs, podcasts, social network sites (e.g. Facebook, LinkedIn), microblogging (e.g. Twitter), photography platforms (e.g. Instagram. Flicker), wikis (e.g. Wikipedia, WikiHow) and video streaming platforms (e.g. YouTube, Vimeo) opened a door for the broad and diverse dissemination of video, in particular educational video (Kent, 2015; Welbourne and Grant, 2015). This kind of formats allow many outlets for debate and discussion on video content. The videos can be seen, commented, and shared not only in specifically dedicated platforms like YouTube, but also in other platforms whose main purpose was not initially video dissemination, like Facebook, Twitter, Instagram but are now "fast becoming an ideal platform for science programming." (Kent, 2015). Viewers have changed from being passive consumers to active participants (Babu and Gopalaswamy, 2011; Welbourn, 2016). Online video is a particularly good tool to reach those born after 1980, a powerful way to disseminate scientific information to an audience accustomed to visual online communication (Erviti and Stengler, 2016).

Additionally, according to Kent (2015), benefits that result from the usage of internet as a platform for video in science communication include: (1) its less formal nature when compared to most other platforms, which may contribute to make complicated science topics seem more approachable to the viewer and lead to informal conversations; (2) the possibilities it gives viewers to pause or re-watch a video, allowing themselves more time to digest more complex ideas, which contrasts with other platforms for video dissemination like television or cinema; (3) the opportunity it gives the viewer to look up a definition, or any other concept that intrigues them, almost immediately; (4) its potential, unlike most of other platforms, for rapid dissemination and amplification of content (Osterrieder, 2013).

Even though the power of social media lies in its strength to amplify the reach of scientific content and its dynamic interactivity, it is also a double-edged sword. The countless opportunities it creates also represent extensive challenges:

1. **It is an environment for potential overload of information:** the overwhelming amount of data available and the proliferation throughout social media of fake news, sensationalized stories, pseudoscience, and alternate facts, with which real science news and outreach initiatives have to compete for public attention, has risen new issues of accuracy, credibility and quality of information (Winter and Krämer, 2012; McClain, 2017)**;**
2. **Scientific communication often doesn't exist in isolation:** in social media, science stories are often not presented in isolation but with associated cues such as comments, shares, or "likes". These cues are viewed by the audiences as markers of accuracy, importance, or popularity of these stories and can both benefit but also hinder the attitude of the public towards science (Brossard and Scheufele, 2013). Studies have shown that, just the tone of the comments following science

stories can significantly modify the way audiences think about science itself. (Ladwig et al., 2011 as cited by Brossard and Scheufele, 2013);

3. **There is lack of control and filters.** The same freedom that allows the positive and constructive dialogue between science and the public to happen, can also feed possible controversy around more sensible topics within the umbrella of science, such as health or climate change. In these cases, the resulting dialogue has not always been either constructive or positive and it makes it that much harder to hear the voice of those specialized in these matter (Dixon, 2016; Pearce et al. 2015).

Because Web 2.0 and social media have great potential but also represent risks that can quickly turn into a pitfall for science communication, it is essential that all the major players – institutions, scientist, journalists, and science communicators – are not only involved and active in the creation, publication, and dissemination of online science stories, but are also well aware of the best practices for communicating in this environment.

I.4. ANIMATION VIDEOS FOR SCIENCE COMMUNICATION: TODAY'S BEST PRACTICES

The internship at ALMA had as its main goal the creation of a series of animation videos to communicate ALMA itself, the way it operates, and the science produced with it. Therefore, it felt necessary and relevant to gather both (1) the best practices on using video for communicating science in today's social media landscape and adapt their model for the purposes of this project; (2) make a review, in no way extensive, of some of the best examples of animation being used in science communication today, and the main strategies used by their creators to maximize the engagement of their audience.

The following list of best practices was draw from both the work of Welbourne and Grant (2015) and Yeo (2015). The first, analyzed nearly 400 videos on YouTube and created a compilation of tips to communicate science trough video in this platform, and even though those tips were created for and mainly apply to YouTube, most can be easily extrapolated to other social media platforms. The second, adapted the 6 key principles to create ideas that stick first described by Chip and Dan Heath's in their book, *Made to Stick (2007)* to the context of science and social media:

1. **Chose an audience.** Choosing a target audience and understanding it allows the author(s) to create the content with special attention to the characteristics of that audience, such as how much they already know about the topic to be communicated, what are their general opinions about it, and what's the goal they pursue by watching the video, among other. Taking these factors into account allows the production of content that connects and engages the audience it was created for.

2. **Focus on simplicity and stay focused.** As science is a broad topic, divided in several other topics that are broad themselves and often correlated, it is important to focus, on each video, on a specific topic. It is important to make sure the core scientific message is identified, isolated and succinct enough to be understood by the audience without it getting lost on details or correlations with other topics. This often represent a challenge to researchers as they are in general more knowledgeable than the audiences to which they are communicating, and often overestimate their understandment. Simplicity is not the equivalent of "dumbing-down" a certain idea, but the ability to express it in a to the point manner.

3. **Get to the point and try to do it in an unexpected way – in social media it is important to both attract and retain the attention of the user.** Introducing the topic of the video and the core idea that is being communicated in the first moments of a video is key to attract and keep the attention of the audience. At the same time, it is necessary to use the unexpected to do both too. The unexpected will create surprise that will grab the viewers' attention and also as the potential to create a gap between what the person knows and what they wish to know, cultivating curiosity and motivating the viewer to keep on watching. In science communication it is relatively easy to keep the audience attention as scientific research is inherently mysterious and invoke curiosity, it is therefore important to focus on attracting the viewers' attention in the first moments of the video.

4. **Give the audience an anchor.** If the goal is to create a channel, a series, or even to simply to have videos associated with a specific institution, it is important to

have a consistent visual image and style from video to video, as it allows the audience to better connect with the institution, channel (e.g. On YouTube), etc. This can be achieved through several different strategies, for example: having a consistent presenter in the case of vlogs, interviews, or recorded presentation; or have a consistent and distinctive design and style in the case of animation.

5. **Appeal to emotion and tell a story.** As previously discussed in this report, messages and concepts that appeal to emotions tend to connect better with the audience and encourage engagement. There are several distinct ways of appealing to emotion, from showcasing their self-interest – the audience realizes the importance of the message for their personal wellbeing (like in climate change, or health related sciences) – to telling a story. Narratives can not only capture and retain the viewer's attention, but also, as defended by Yeo (2015) "convey clear messages that make science relevant to people's lives.". They have been shown to have a significant impact on public attitudes towards many issues, including science.

6. **Create something stunning.** In today's participative landscape the role of visual science communication changes. It is not sufficient anymore that visuals are informative and explanatory of the concepts they aim to disseminate, they need to be aesthetically pleasant, so they attract the audience and engage them. (Rigutto, 2017). According to Norman (2007) as cited by Rigutto (2017) "attractive things work better because interacting with them is more pleasant".

Many science communication online videos in today's social media use animation as one of the visual elements, but not the exclusive one. For the purpose of this report, however, the following brief analysis will be focused on videos that are animated in their entirety, as the final goal of my internship was to create a series of videos with the same characteristic. The upcoming examples and their broad success are a demonstration of how well this method is being received by present-day audiences.

AsapScience

With 7 300 000 subscribers and almost a billion views (1 000 000 000) (fount: socialblade) the YouTube channel ASAPscience is the most popular animation video channel in today's social media landscape. It was created in 2012 and since then videos are uploaded weekly. Those videos, which are usually shorter than 5 minutes, have an animation style that is simple, informative, relying on colorful drawings made on a white board, with occasional inclusions of props or objects animated with stop-motion.

The videos focus on a variety of scientific topics such as biology, chemistry, and physics. The work of the authors, both biologists by formation, is often the result of the interaction with the public: many videos are born from the questions and topics suggested by the audience itself. Their dialogue has created a strong world spread community, with some of the videos already being translated into 9 languages (fount: crunchbase). The fact that the content of the channel is so focused on the audience and what they whish to know, make the scientific content communicated on the channel relatable, a key aspect when it comes to holding the interest of their viewers. Another very particular characteristic of this channel is the way the videos are titled. On an interview to *Business Insider*, the authors reveled that, from a very early stage, it was evident how important the title of the videos was: "It had to be very relatable to people in order for them to want to watch it.". A strong/attractive title which tackles topics the audience is already experiencing or wondering about is key to the success of the channel: "What If The World Went Vegetarian?", "Could We Record Our Dreams?", "What would happen of you never went outside again?", "Humans In 1000 Years" and many others. This allows the creator to use people's natural curiosity to approach harder and more abstract scientific ideas.

Kurz Gesagt – In a Nutshell

Created in 2013, and reaching almost 5 500 000 subscribers today, the YouTube channel *Kurz Gesagt - In a Nutshell,* creates animated videos focused on technical and scientific subjects, often tackling the border between science and philosophy.

The channel, with an audience of around 10 000 000 people per month, (fount: socialblade), publishes videos that run between 2 to 7 minutes and follow a lot of the previously mentioned good practices for online science communication. From telling a story that appeals to the viewer's emotions, to the giving the audience both an anchor and stunning engaging visuals in their unique characteristic design and animation style. In order to keep it simple and distill the often complex scientific content, the authors regularly resort to the use of visual comparisons and metaphors. Not only to perform everyday life comparisons that close the gap between the public and the abstractedness of some concepts, but also to show different orders of magnitude in sizes, distances, time, and degrees of complexity. “The animation allows them to take a rather abstract concept and distill it into a simple visual comparison” (Kent, 2015).

Additionally, the channel uses a mildly humorous approach to introduce or further explain some of the concepts on their videos. In her article *Making People Laugh About Science. It's a Good Thing*., Jarreau (2014) points out different studies that showcase the benefits of using humor when communicating science: (1) it makes it more appealing to the audience (Pinto et al., 2013); (2) it may help the viewer better remember the presented information (Southwick et al. 2002) and (3) it helps grab the viewers' attention and promotes their engagement (Pathmanathan, 2014).

TED-Ed

Unlike the previous two examples, which have a set of fixed authors creating and producing the majority of the videos – two Biology majors in the case of *AsapScience* and a design studio team in the case *Kurz Gesagt – In a Nutshell* – TED-Ed follows a different approach: the animations are the result of collaborations between expert educators – scientists, teacher, science communicators – and animators from varied backgrounds and different places in the world.

TED-Ed is both a website and YouTube channel which focus is to create, according to their own words: “lessons worth sharing”. TED-Ed Originals are three to five-minute explanatory animation videos created by the above-mentioned collaboration and when paired with questions and resources, they make up what is referred to as TED-Ed Lessons (fount: TED-Ed website, About section). Their aim is to capture and amplify great lessons to the online community with a special emphasis in students and teachers. The videos cover a wide range of concepts which include, but not exclusively, science related topics.

The YouTube Channel alone has more than 57 million subscribers, and 800 million views. Since its creation 2011 it has developed a library of more than 1 300 videos, being a prime example of the value of collaborations between scientists, educators and artists for science communication and education. As TED-Ed's director states “The videos (…) are resources that teachers can use to excite, inspire, and bring to life lessons that are already being taught. (…) The great thing about TED-Ed is that educators can use these tools however best suits their – and their students' – needs.” (Schwartz, 2012). The content is not meant to be a substitute for what happens in the classroom, rather a support. The power and value of video and particularly animation as a support for science learning and education has been emphasized in the last couple of decades (e.g. Fisk, 2008; Berk, 2009, Kind & Evans, 2015; Yellepeddi and Roberson, 2016; Bohlin et al. 2017; Scholl, et al. 2016; Cruse (20??); Aravopoulou et al., 2017), specially for the new generation of students , who have grown up in the internet and social media era.

Adding to the previously gathered good practices for using video to communicate science, today's most successful animation video initiatives point to the value of the following strategies:

1. **Create content highly focused on the audience,** including the titles that should be relatable to that same audience.
2. **Use comparison and metaphors to simplify ideas,** this makes them more familiar and more capable of being visualized by the audience;
3. **Take advantage of mild humor,** as it can be used to foster the viewers engagement;
4. **Base the content in the collaboration between scientists, communicators, and artists.**

The potential and capacity of video and, in particular, animation to communicate science in modern society is clear. It lends itself greatly to communicate complex scientific content and ideas, and promotes engagement. It does so by (1) representing the un-filmable and abstract; (2) making use of visual stimuli, storytelling and appealing to emotions; (3) being a very versatile channel, that can be used in many different platforms, in very different contexts and all over the world. Additionally, animations are an ideal format for communicating science in today's social media landscape. More and more information is communicated through video, and for science it is a less formal, more approachable and entertaining way of contacting the public, opening the chance for dialogue between the two.

PART II

COMMUNICATING ALMA

The purpose of this second part is to introduce the Atacama Large Millimeter/Submillimeter Array (ALMA). Delving on the how and why the biggest ground-based telescope to date came to life, the expectations of the scientific community for the observatory and the nuances of being the collaborative effort of different nations. Additionally, it focuses on the potential and challenges of communicating astronomy, radio astronomy and ALMA itself.

II.1. ALMA: A BRIEF INTRODUCTION

"*All human beings share the desire and fascination to understand the Universe, asking ourselves similar questions about our cosmic origins: Where do we come from? Where are we going?"- Mattheus de Graauw, ALMA Director 2008-2013*

II.1.1. THE LARGEST GROUND-BASED ASTRONOMY PROJECT IN THE WORLD

The Atacama Large Millimeter/Submillimeter Array (ALMA), is a state-of-the-art international astronomy facility, a telescope, design to observe the light emitted by some of the coldest objects in the Universe. As this light has wavelengths between 0.3 and 9.6 millimeters – falling in the infrared light and radio waves categories of the spectrum of light – ALMA is considered a radio telescope. Composed by 66 high-precision antennas that can be spread over distances up to 16 kilometers and work together as one single telescope, ALMA is the largest radio telescope and ground-based astronomy project in existence.

Three different sites compose ALMA infrastructure, all of them in Chile, working together to allow the operation of the observatory:

- **Santiago Central Office (SCO),** ALMA's administrative offices and headquarters, are located in Santiago, the capital city of Chile. Astronomers as well as administrative and technical professionals work at these facilities to support the rest of the team at the observatory in northern Chile. In SCO the data collected by the antennas is processed and converted into interpretable data packages and distributed around the world. This was the main location of my internship as it is the base location for the Education and Public Outreach Office (EPO).

- **ALMA Operations Support Facility (OSF)** is located at an altitude of 2900 meters in the Atacama Desert, Chile. 30 kilometers separate it from San Pedro de Atacama and 28km from the location of the 66 ALMA antennas. It is the base camp that serves as the focal point for most of the observatory activities and routine operations. It is the workplace of the astronomers and teams responsible for maintaining the proper functioning of all the telescopes. The OSF hosts the antenna control room, laboratories, offices and living quarters. It is also where the antennas are maintained. One week of my internship (19^{th} to the 26^{th} of December 2016) took place at the OSF.

- **Array Operation Site (AOS)** is located 50km east from San Pedro the Atacama, in the Chajnantor Plateau at an altitude of 5000 meters in the Chilean Andes. It houses the 66 high-precision antennas (individual radio telescopes themselves) that compose ALMA and, on the technical building, the super computer that receives and processes all the data from those antennas: the correlator.

II.1.2. “IN SEARCH OF OUR COSMIC ORIGINS”

The millimeter and submillimeter radiation that ALMA aims to receive is heavily absorbed by water vapor in the Earth's atmosphere, hindering their collection on Earth's surface. That is why ALMA antennas were located at an altitude of 5000 meters in the Atacama Desert. This desert is one of the driest places on Earth. It is very high, has sparse clouds and very little light or radio interference, which makes the atmosphere above it largely transparent. Additionally, the fact that the antennas are reconfigurable into baselines ranging from 15m to 18km, allows ALMA to perform astronomic observations with unprecedented resolution (sharpness and clarity) – a factor of ten better than the Hubble Space Telescope.

This way ALMA provides astronomers the opportunity to produce transformational science in a wide range of astronomy and planetary science subjects, mostly related with the cold Universe – regions that are optically dark but shine brightly in the millimeter portion of the electromagnetic spectrum.

As implied by ALMA's moto "In search of our cosmic origins", the radio telescope observations aim to shed light over some of the biggest questions in astronomy research: (1) the origins of galaxies in the edge of the observable Universe; (2) the birth and formation of galaxies, stars and planets and therefore the birth of the Milky Way, the Solar System and planet Earth; (3) the complex chemistry of the Universe, hopefully providing some clues to the origin of life, itself.

II.1.3. AN INTERNATIONAL COLLABORATION

A large-scale astronomical observatory like ALMA is not a project that can be developed or operated by one single country. ALMA became possible through international collaboration at a global level and agreed share of human resources, technologies, and funds (fount: NAOJ website). It is the result of a partnership between Europe, North America, and East Asia in cooperation with the Republic of Chile.

ALMA is **funded** in Europe by the European Organization for Astronomical Research in the Southern Hemisphere (ESO), and its 16 member states: Austria, Belgium, Brazil, Czech Republic, Denmark, Finland, France, Germany, Italy, the Netherlands, Portugal, Spain, Sweden, Switzerland, Poland and United Kingdom; in North America by the U.S. National Science Foundation (NSF) in cooperation with the National Research Council of Canada (CNRC-NRC); and in Japan by the National Institutes of Natural Sciences (NINS) in collaboration with the Academia Sinica (AS) in Taiwan, and the Korea Astronomy and Space Science Institute (KASI) of South Korea.

Figure 1. ALMA partner institutions and their locations on the globe. (©ALMA (ESO/NRAO/NAOJ))

ALMA is **operated** on behalf of Europe by ESO, on behalf of East Asia by the National Astronomical Observatory of Japan (NAOJ) and on behalf of North America by the National Radio Astronomy Observatory (NRAO).

A series of organizational obstacles arises when a project is the result of a worldwide collaboration. In ALMA's case there are at least three different administrative systems, mentalities and cultural backgrounds working together to achieve a common goal. In order to take maximum advantage of the contribution of each partner for the observatory and promote its most effective use, a complex management structure is necessary (Wild, 2010). The Joint ALMA Observatory (JAO) was created by the three partners to synchronize the activities of the Executives in Europe, North America, and Japan, as well as on the ALMA site near San Pedro de Atacama. It is responsible to provide an overall management structure for ALMA and to lead the ALMA construction, commissioning, and operation (fount: ALMA brochure 2007).

II.1.4. A BRIEF HISTORY OF ALMA

From the 1980’s through the 1990’s, researchers in Japan, Europe, and North America were respectively working in isolation to create a large radio telescope — the Large Southern Array (LSA) of Europe, the Millimeter Array (MMA) of the United States, and the Large Millimeter Array (LMA) of Japan. However, it soon became evident that the ambitious projects could not be developed by a single community, and the first step towards the creation of a single unified effort that would become ALMA took place in 1999, when NRAO of North America and ESO of Europe agreed to pursue a common project that merged both the MMA and LSA (fount: ALMA website, Origins).

Later in 1999 a series of resolutions and agreements led to the choice of "Atacama Large Millimeter Array", or ALMA ("Alma" means "soul" in Spanish and "learned" or "knowledgeable" in Arabic.), as the name of the new array. In Tokyo on the 25th of February 2003, a resolution was signed between the North American and European parties to jointly construct and operate ALMA (Perebo, 2003). After several years of mutual discussion, on the 14th of September 2004 the National Astronomical Observatory of Japan joined the consortium.

One year later in 2005, the foundations were laid on the Chajnantor Plateau, initiating the construction of the observatory. Science operations started in 2010 and the radio telescope was fully operational on its inaugurations on the 13th of March of 2013.

II.2. ALMA's EDUCATION AND PUBLIC OUTREACH (EPO)

ALMA Education and Public Outreach (EPO) programme is a global collaboration that seeks "to communicate the excitement, discovery, and value of the ALMA mission, science, and technology to the broadest possible international audience effectively." (Adams et al. 2014).

The overall programme is of the conjoint responsibility of the executives: ESO, NRAO and NAOJ and is conducted by the JAO. ALMA's EPO Office (JAO EPO Office), located in Chile, and the place where my internship took place, is responsible for the coordination of the international EPO program on a day-to-day basis and in charge of the creation and implementation of ALMA EPO Program in Chile.

In collaboration with the Executive EPOs, the JAO EPO Office is responsible for implementing and coordinating the following seven secondary programmes derived of the overall EPO programme (Adams et al.,2014):

1. **Science Community Outreach –** This programme focuses on communicating ALMA capabilities, potential and achievements to the professional science community. Mainly by designing and deploying informative exhibits, support materials, and staff to important science meetings around the world.

2. **Online Outreach -** The internet and social media are ALMA's most important communication tools, as they are prime and unparalleled platforms available round-the clock, with the ability to reach big audiences all around the world. ALMA web content includes news releases, media resources, educational materials and programmes, images and illustrations, animations, video, podcasts, presentations, and more.

3. **News & Public Information –** This program has as its main objective the creation and distribution of ALMA scientific discoveries, news, and information to the international online and print news media, not only by the more traditional

medias such as printed, television, online journalism, but also using brochures, DVDs, books, podcasts, and public exhibitions.

4. **Formal Education –** This programme aims to develop both online and hard copy curriculum support products for K–12 educators and students, as well as assist education communities through the development of training and workshops for teachers. Due to the multidisciplinarity of radio astronomy and the science done by ALMA, several different areas - which include physics, engineering, Earth sciences, life sciences, and culture (where the Atacama Desert as a key role) – are addressed in the formal education materials and training done by the EPO. This programme faces a significant challenge: addressing the curriculum requirements of the many countries participating in ALMA.

5. **Informal Education –** This programme is responsible for establishing links between ALMA and science centers, planetariums, natural history museums, observatory visitor centers, outreach activities and expositions that are visited by public audiences seeking to broaden their understanding of science.

6. **Astronomical Data Visualization –** This programme focuses on investigating novelle approaches to mm/sub-mm data visualization, as it is believed that ALMA capabilities to reveal breathtaking astronomical images are a key aspect in capturing and maintain the attention of the public. This programme bets strongly on the close collaboration between ALMA science and art.

7. **Public Affairs** – ALMA as a special location, and with that location comes great responsibility. The partners have always placed a high priority on their duty to: (1) conserve archeological sites; (2) preserve local fauna and flora; (3) establish and maintain excellent relationships with the surrounding communities. Therefore, the Public Affairs programme is responsible for actively promoting ALMA science, technology, and value to the Chilean national and regional governments, and to the Chilean people.

Furthermore, it is particularly relevant to mention the key role JAO EPO Office has in the promotion and institution of scientific and educational undertakings in Chile.

Communicating the results of an international project to a global audience is never an easy task and is often one that involves a series of challenges that go beyond the ones primarily faced when communicating the science produced itself. These challenges faced by astronomy, but also radio astronomy and, in particular, ALMA, will be addressed in the following section. Despite all the obstacles, there is also a distinguishing set of advantages and potential for public science communication that comes with astronomy and space sciences which will also be discussed below.

II.3. THE POTENTIAL AND CHALLENGES OF COMMUNICATING ASTRONOMY, RADIO ASTRONOMY AND ALMA

II.3.1. THE POTENTIAL

Astronomy can play a special role within public science communication. It has special, though not unique, advantages when compared to other fundamental sciences:

1. The particular power to touch people's emotions and invite emotional involvement by nurturing human imagination and intrinsically connect with long-standing questions about our origins, our place in the Universe and whether not we are alone in it;
2. The naturally interdisciplinarity of astronomy – an umbrella discipline that embraces a series of core sciences like mathematics, physics, chemistry biology and geology, linked with technical and instrumentational disciplines such as optics, electronics and data analysis – makes it a especially good introduction to other less wonder-inducing disciplines;
3. The possibilities it offers to create a narrative, as the many science fiction stories created throughout history make evident;
4. The results and products of Astronomy research often produce strongly appealing visual whit great illustrative and engaging power, showing captivating scientific phenomena in aesthetically beautiful form (National Research Council, 2001; Heck and Madsen, 2003).
   As underlined by Madsen and West (2003) "In short, astronomy attracts a wide spectrum of people and may serve as a powerful vehicle for improving the public awareness and understanding of science."

Radio astronomy, in turn:

1. Lends itself easily to science outreach as some of the most interesting aspects of astronomy are observed and studied in the radio portion of the spectrum. These include primordial galaxies, forming planets, pulsar, neutron stars, black holes and other phenomena that often captivate people's interest.
2. Its observations can take an astronomically familiar object and reveal a completely new and more interesting view of it, showing the to the public the why's and benefits of doing astronomy with superhuman vision, and how

much more information can be obtained, and discoveries made with this kind of astronomy.

When it comes to ALMA and the potential it offers to communicate astronomy, and science in the bigger picture, the main advantages are related with:

1. The massive scale of the project, its visibility, and the high respect it receives within the scientific community, that ultimately reflects on the appreciation of the public.
2. Being a collective effort of different institutions and nations gives ALMA the chance to reach a more diverse and widely spread audience. As its communication is not only done by the observatory itself and its direct staff, but also by the different partners and their respective partners widely spread across the globe, ALMA as a reach bigger than a lot of other radio astronomy and astronomy related institutions.

II.3.2. THE CHALLENGES

Despite all its numerous advantages, astronomy also possesses certain characteristics, which though not unique to this scientific area, hinder its communication to the public:

1. With a few exceptions, in Astronomy it is impossible to visit or touch the objects of research and study.
2. It often "produces" incomprehensible big numbers, with temporal and spatial scales incredibly difficult to understand and comprehend. Therefore, astronomical observations and concepts tend to acquire an abstract and distant feeling. The public develops a notion that astronomy, though fascinating, relates with concepts that are far away and unrelated to their everyday life.
3. Even though many astronomical observations imply a spectacular result, that result is often only representable in a very indirect manner. A complex idea and concept very difficult to put into words alone (Hurt, 2005).

When it comes to ALMA and the particularities of communicating astronomy outside of the visible spectrum, a number of new challenges arises. Radio astronomy outreach, as happens with other non-optical astronomies, does not have a background as well-established as optical astronomy outreach (Varano, 2007). This happens because:

1. “Most of the general public is not even aware of the concept of “other” types of astronomy.” (Watzke and Arcand, 2005). For a great majority of the audience, astronomy consists of observing objects in the sky through the eyepiece of a telescope. The telescope is perceived as a magnifier of human vision, i.e.: an instrument that makes a small object look bigger (or a more distant object look closer) and nothing else. The public is often unaware that a telescope indeed amplifies the faint light from an object, but also detects light beyond the optical window, including radio waves (Travis et al., 2017);
2. Even when the public is aware and familiar with the existence of radio waves as part of their daily lives, in radio communications for example, it is not aware of the fact that radio waves are a kind of light, just as visible light, or that celestial bodies emit radio waves;
3. Radio astronomy deals with complex fundamental concepts that often lack direct visualization or images. Even in the cases where images are indeed present, they are not as obviously compelling as the average image obtained through an optical telescope.

   Images obtain through radio astronomy are the “translation” of what the telescope can see into something our eyes can see and our minds can understand. It's common for the public to question those images: “Is this image real?” or “Is this what it really looks like?”, this makes the task of communicating it to the public a difficult one (Watzke and Arcand, 2005; Varano, 2007; Rector, Arcand & Watzke, 2015 as cited by Travis et al., 2017).

Additionally, for ALMA, such as happens with other scientific institutions, clear communication of the goals and accomplishments of the scientific programme can be challenging. Not only due the complex topics addressed, but also due to the wide range of audiences to reach.

Even harder to deal with are both the fact that ALMA target audiences are, in their majority, a long distance away from Chile, spread all over the globe and speak a great diversity of languages (Goldfarb et al., 2014; Hiramatsu, 2015).

Communicating astronomy, radio astronomy and ALMA as an observatory, as well as the science achieved through it has a lot of potential, but also great challenges. Therefore, the goal of my internship at ALMA was to create a project that would not only enhanced the potential but also find a solution for the challenges and difficulties faced by the radio telescope's Education and Public Outreach Office.

PART III

#WAWUA: COMMUNICATING ALMA THROUGH ANIMATION VIDEOS

So far, both the power of animation as a tool for science communication in modern society and the potential and challenges of communicating ALMA, radio astronomy and astronomy have been discussed. The purpose of part III is to show why using the first might be the answer to heighten the potentials and face the challenges mentioned in the second, unveiling the reasoning behind the creation of #WAWUA ("Why do Astronomers Want to Use ALMA?"): the project developed throughout my internship at ALMA's Education and Public Outreach Office (EPO). This part discusses the ideas and goals behind the project; as well as every step involved in the production of the animation videos that compose it.

III.1. THE GOALS

The goal of my internship at ALMA was to create and develop, in an independent manner but with the support of the Education and Public Outreach (EPO) team, a project that would amplify ALMA's reach within its diverse and globally distributed audiences and give them a better understandment of radio astronomy and ALMA itself.

As a result, and after careful consideration, it was decided that a series of animation videos would be best solution for the question at hand, as it would allow the applied use and development of my skill set and, at the same time, provide ALMA with a valuable, versatile project that could be used to communicate in diverse situations and occasions.

The reasons behind the use of animation videos and the principles guiding them during my internship were simple: (1) make the most out of ALMA's potential, (2) find solutions for the challenges EPO team encounters when communicating the radio telescope and its science, (3) follow the best practices of similar initiatives today to do so.

1. **Potentiate ALMA's best characteristics.** As a telescope, ALMA enjoys some of the best communicational advantages of astronomy: the proneness to touch people's emotions and nurture their sense of wonder and curiosity; the potential to produce strongly appealing and beautiful visuals with great illustrative power; the easiness with which it lends itself to create narratives while searching for the answers to long-standing questions about our origins and our place in the Universe. The use of animation videos in this project allows and aims for a platform to explore these advantages by offering compelling and entertaining visual storytelling. One that integrates a narrative, aesthetically beautiful visuals, and emotionally engaging content.

2. **Fight some of the main challenges faced by the EPO.** Precisely as it happens with the benefits, ALMA also shares some of its main communication and outreach challenges with astronomy. This area of science often deals with incomprehensible big numbers and temporal and spatial scales incredibly difficult to grasp and represent; study objects that are impossible to visit or touch; complex ideas and concepts that are very difficult to put into words alone. Using animation offers a solution for these obstacles by: representing and illustrating situations and content difficult or impossible to film; allowing for great spacial and temporal representation, for example by showing long periods of time in brief instants; and last, but not least, giving the viewer something concrete to represent abstract concepts.

Moreover, there are the added challenges of communicating astronomy that focuses on non-visible light, in this case, radio astronomy. As the public is often not aware of the existence of light (radiation) beyond the visible spectrum and consequently not aware of the existence of astronomy that focuses on these other kinds of light, one of the main focuses and aims of #WAWUA was to present these ideas in a way that would be easy to grasp and visualize, a task made easier by using animation. Exactly because it deals with non-visible light, radio astronomy often handles complex fundamental concepts lacking direct visualization or images, and once again animations come as a solution, representing the impossible to film and the poorly represent by words.

Additionally, the versatility of animation as means of communicating science – from an excellent format for social media, to a great support to teachers in class and other outreach activities – also helps facing one of the main challenges faced by ALMA EPO: reaching its global, diverse, and wide audiences.

3. **Guide the work by the best practices in today's animation for science communication landscape –** after gathering the best practices related with animation video as a format for science communication (see Part II) the creation of the #WAWUA videos respected the following guidelines:

    - Focus on simplicity and stay focused;
    - Be informative and accurate;
    - Create short videos that get to the point quickly;
    - Know the audience and create content focused on that audience;
    - Tell a story and appeal to emotion (ideally applying mild humor);
    - Use comparisons and metaphors to make ideas familiar and visualizable;
    - Design aesthetically beautiful and colorful visuals;
    - Explore the collaboration between scientists, communicators, and artists.

III.2. THE AUDIENCE

As an international astronomy facility, ALMA as a great variety of target audiences. These include stakeholders as governments and policy-makers (among others the partner institutions, the member states of those partner institutions and the host country of Chile), the international astronomy/astrophysics community (astronomers/astrophysicists, research institutes and universities and the scientific community in general), the media, the general public (citizens), the local community on the Atacama Desert and in Chile, teachers and students (from k-12 student to graduate) and potential new candidates such as students, graduates and professionals.

Before starting the creation of the episodes, the members of ALMA's EPO team based in SCO and myself came together to discuss the target audiences of the project, the messages and its basic format.

Even though ideally, each product created for science communication is tailored to a specific audience (Grorud-Colvert et al., 2010), my 9-month internship at ALMA was a time and resource-limited situation, where there was a need to address multiple target audiences with a single product. Therefore, it was agreed that, taking full advantage of the versatility of animation, the created videos could serve three of the seven EPO secondary programmes (see Part II): online outreach, formal education, informal education. In other words, #WAWUA was mainly tailored to two different target audiences: K-12 teachers and students and the general public (citizens).

The animation videos resulting from the internship would be used to reach their target audiences as (1) online and social media content – offering a higher chance of reaching nontarget audiences, viewers that were not considered at the time of material development –; (2) optional support or educational supplement material for K-12 classes mainly in Chile, but also around the world; and (3) content integrated in ALMA outreach activities and expositions.

Understanding the two different target audiences and their needs to develop a project that would be focused on both was critical step. It was agreed that the content of the videos should be jargon-free, understandable (and enjoyable) by a 10-year-old and appreciated by already interested audiences.

Because ALMA EPO oversees the elaboration and implementation of the Chilean ALMA EPO Program and is responsible for the promotion of scientific and educational undertakings in Chile – including exhibitions and participation of ALMA astronomers in outreach activities and science-related events in Chile – and because ALMA social media is as well in both languages, the #WAWUA project was conceived to exist in both English and Spanish.

III.3. THE MESSAGE

After the initial meeting it was decided that the messages to be put forward through the videos should be simple and engaging. I was responsible to suggest the topics to be featured in the videos, create a plan with the key overall messages to be presented and explained per episode and, in the end, pitch that same plan to the EPO team for feedback and approval.

Therefore, I decided to divide the messages to be transmitted by the overall series and the individual episodes in two groups: the primary key "take home" messages, and the secondary episode-related messages.

The primary key "take home" messages were the ones to be communicated throughout the series, common to every video/episode. They could be transmitted either directly or indirectly:

- ALMA is the best (higher sensitivity and higher resolution) and most ambitious radio telescope in the world;

- ALMA opens a new window to the study of the cold universe: the birth of starts and planets, the galaxies that formed soon after the Big Bang and the molecules that could have been the building blocks of life are all part of the cold universe invisible to optical astronomy;

- ALMA discoveries so far are just a very small example of all its potential, and every new discovery opens doors to new questions, new research, new astronomy;

- To allow for this kind of discoveries ALMA is pushing the boundaries of technology and engineering and will keep on doing so;

- ALMA contributes and brings benefits to the society. It contributes to the human endeavor of answering questions about our origins and place in the Universe and it drives innovation and brings new solutions for technology and industry.

Based on these key primary messages, it was decided that the main focus and title of the series of 5 animation videos would be #WAWUA: "Why do Astronomers want to Use ALMA?" as answering this question would not only allow the showcase of ALMA's biggest advantages, but also pair those up with basic science concepts and facts that would provide the viewer with more information and a better understanding of astronomy and radio astronomy overall, fighting some of the biggest misconceptions around those topics. The topics of the 5 different videos, and the secondary episode-specific messages to be transmitted, divided by "Basic concept" and "What ALMA offers" are described in the table below:

Table 1. Topics and "Take Home" messages for the 5 Episodes of #WAWUA. The "Take Home" secondary episode-specific messages are divided by: "Basic concept", referring to the basic scientific/astrophysics concepts to be conveyed and explained during the episode; and "What ALMA offers", which in turn denotes the way ALMA relates directly or indirectly with those concepts or how it uses it for its advantages to study the Universe.

#WAWUA: "Why do Astronomers Want to Use ALMA?"		
EPISODE	**TOPIC**	"TAKE HOME" MESSAGEs
I	Because ALMA sees invisible light	**Basic Concepts:** Light The electromagnetic Spectrum
		What ALMA offers: The advantages of seeing radio waves instead of visible light.
II	Because ALMA as the sharpest eyes of all for the light it sees	**Basic concepts:** Resolution and sensitivity Interferometry
		What ALMA offers: The possibilities of antenna dynamics for interferometry and the "why" behind different configurations allowing different resolutions and sensitivity.
III	Because it will help answer the question "Where did t life come from?"	**Basic concepts:** Nuclear fusion The creation of atoms of different elements
		What ALMA offers: The possibility to observe molecules in cold space and how that may allow a better understanding of the origins of life.
IV	Because it will help answer the question	**Basic concepts:** Space/Time

	"How were the first Galaxies and stars after the Big Bang?"	**What ALMA offers:** The possibility to observe galaxies in the early universe and therefore galaxy evolution
V	Because it will help answer the question "How are stars and planets born?"	**Basic concepts:** Star and planet formation and development
		What ALMA offers: The possibility ALMA offers to observe through dust and how that allows the study of stars and planets around them as they form in gas clouds.

III.4. THE FORMAT

All the 5 videos that constitute the final #WAWUA series have an approximate duration of 2 minutes and are based on a 300-word script. This makes for an average of 150 words spoken per minute of video. The adopted duration of the videos was based on the evidence (May et al., 2011; Ahmed et al., 2015) that in both today's social media and classroom environments it is essential to keep the content short and direct to maintain the viewer's attention.

Figure 2. Episode IV: "ALMA is a Time Machine!" screenshots.

All episodes of the series share a cohesive design and animation style, giving them a characteristic visual identity. This shows the audience that, even though every video is a standalone and can be watch independently, it is still part of a series that aim to answer the same broader question: *Why do astronomers want to use ALMA?*

Additionally, all 5 different episodes of the series all follow the approximate same structure:

1. Shortly introduction the topic of the episode, as well as the basic concept addressed in it (often with a question and/or an everyday life reference);

2. Development and explanation of basic concept often recurring to metaphors, comparisons, and examples of everyday life;

3. Introduction to the way ALMA relates to the basic concept presented (its role on the science related to it, the questions it might help answer, etc.)

4. Finish on a positive note, referring to how what is known is just a scratch in the surface of everything that can be observed and studied with the help of ALMA

This structure easily lends itself to a narrative style, allowing for the integration of a story. With adaptations for the different contents and scripts, the structure follows the same plot: there is a problem or a challenge that needs to be solved and the story follows the steps until a solution or alternative is proposed.

III.5. THE PRODUCTION PROCESS

III.5.1. BACKGROUND RESEARCH AND SCRIPT WRITING

This step involved the building of a knowledge base of the topic selected for each episode. It was carried out right after the selection of the topics for the different episodes and involved online research, the review of diverse printed materials produced by ALMA and the contact and discussions with ALMA staff and astronomers, who have firsthand knowledge of the addressed topics. The combination of all the above mentioned allowed for the creation of a repository of facts and important points to be used in each of the different episodes.

This process, even though time consuming (three to four days per episode), was essential for the development of #WAWUA and my internship. As my level of knowledge of astronomy and related topics was limited – not only was I not familiar with some of the terms and concepts to be discussed in the videos, but also most definitely not knowledgeable enough in any of the addressed concepts to be able to create an engaging story and script – the process of background research was essential to gain a clear understanding of the concepts at hand and their relevance, and was detrimental to my ability to afterwards create the visual storytelling present in the videos.

Ahmed et al. (2015) served as a base guide for the entire production process. In their article *The Process of Creating Online Animated Videos to Overcome Literacy Barriers in Health Information Outreach* they wrote: "We have discovered that the most useful way of working with background materials is by separating them into individual facts or concepts and marking those with specific categories. It is also important to cite the sources, for ease of later review and quality control.". The same principle was used in the background research I developed in my internship and by the end of each episode-specific research the process the outcome was a document composed by a series of several different quotes and their sources.

Even though not in their entirety, these quotes were used as the background information, the ingredients, to create the story of the episodes, viz.: their script. For any discovery, concept or idea in any field, it is possible to ask a series of question that will lead to a new insight, to the "hook" that can be used to draw the public: "One of the first is: what is the simplest and clearest way of expressing the science I am presenting?" (Berlin, 2016) these was the question that served as a pillar to the construction of the scripts.

Choosing the story's focus and direction was not an easy task. It had been previously decided that the episodes would not have specific characters or a plot, as this was what happened in the most currently successful examples of *In a nutshell* or *AsapScience,* with the additional support of the fact that animations that involve this kind of features often require a significantly longer duration and go against #WAWUA's goal of being composed of short and direct videos (Ahmed et al., 2015). However, it was still essential to have a storytelling feeling in the animations. To accomplish this goal the "story" behind every episode followed a simple narrative based on an existing question or mystery and its solution, with a middle step of understanding the question and the concepts that can help find the answer.

Creating the scripts followed therefore, the 4 steps previously mentioned in the format section: (1) finding the right engaging question and use it as an introduction; (2) developing that question and the concepts behind it through metaphors and everyday life examples, while often offering the solution; (3) explaining how ALMA is relevant and related to that question. In some cases, between (2) and (3) there's an additional step that focuses on introducing a problem/obstacle related with the previously addressed question, an in this case (3) focuses on showing how ALMA is a solution to that new problem.

Episode IV for example starts by asking the question: *How can astrophysicists study the story of the Universe if they were not there when it started?* This question introduces the mystery and prompts the viewer's level of curiosity.

Right after, the answer to the question is offered by using a metaphor: *because the universe works somehow like a time machine* (Figure 2.A.) and the idea is further developed and cleared thought an everyday life example: *When you hear a plane, you probably have a hard time spotting it in the sky. You look in the direction where the sound came from, but the plane is no longer there. Well, that's because its sound took some time to reach you, and by the time it did, the plane had already moved on. In a way, you were "hearing back in time"* (Figure 2.B.)*, as the sound you perceived was the one that left the plane seconds before. With light it's exactly the same.*

The following paragraph is dedicated to expose a problem/obstacle: *The problem is when things are very far away from you, it gets to a point where it's impossible for your eyes to distinguish details. Telescopes, especially the ones that see the same kind of light as we do, also have a limit and are not able the detect the light emitted by the first galaxies ever formed, as they are too distant, and their light is too faint.* (Figure 2.C.)

In the end ALMA's relevance as a solution to the problem is explained whilst leaving a door open to new possibilities: *ALMA, with its incredible sharpness and ability to see radio light, can distinguish the dust and gas clouds formed by the first generations of stars in the Universe, and help astronomers understand a little bit more about this early* *phases of time and space, which is fundamental if we want to fully understand our present.* (Figure 2.D.)

Figure 3. Screen shots from episode IV: "ALMA is a Time Machine!" scenes.

The scripts are created to both: (1) be used by the voice actors conducting the voice-over process and (2) as a base to the development of the storyboard and animation processes. Therefore, while creating them, it is important to consider both the audience and the voice actor. The first so that the appropriate language and tone are used and the second so that the writing is based on easy-to-pronounce aloud sentences words, that mimic the way one speaks.

Once the script was finish, it was reviewed by the members of the EPO team and one ALMA astronomer so there were no inadvertent omissions, mistakes, or inaccuracies and edits, suggestions, and corrections could be provided. As the videos needed to be produced in both English and Spanish, after the final version of the script was obtained in English, it was sent for translation. The necessity of keeping the same approximate length and pace of the English script, was pinpointed to the translator, so that the durations and pace of the two different versions of an episode wouldn't be to disparate.

III.5.2. STORYBOARDING

As a pre-visualization of how the videos would unfold, frame by frame (frame should be understood as the main individual “frozen” picture in a sequence of images) #WAWUA's storyboards were hand-drawn as “comic book” versions of the script with each frame corresponding to a panel with both a visual and a written component:

- **The visual component** shows the illustrations present in each frame;
- **The written components,** divided in two, specify (1) in the component on the bottom, the part of script to which the visuals refer to, and (2) in the component that accompanies the illustrations, the motions and overall changes of the different components in each frame, as well as the transition between frames. Is does so through words, numeration, arrows and other elements.

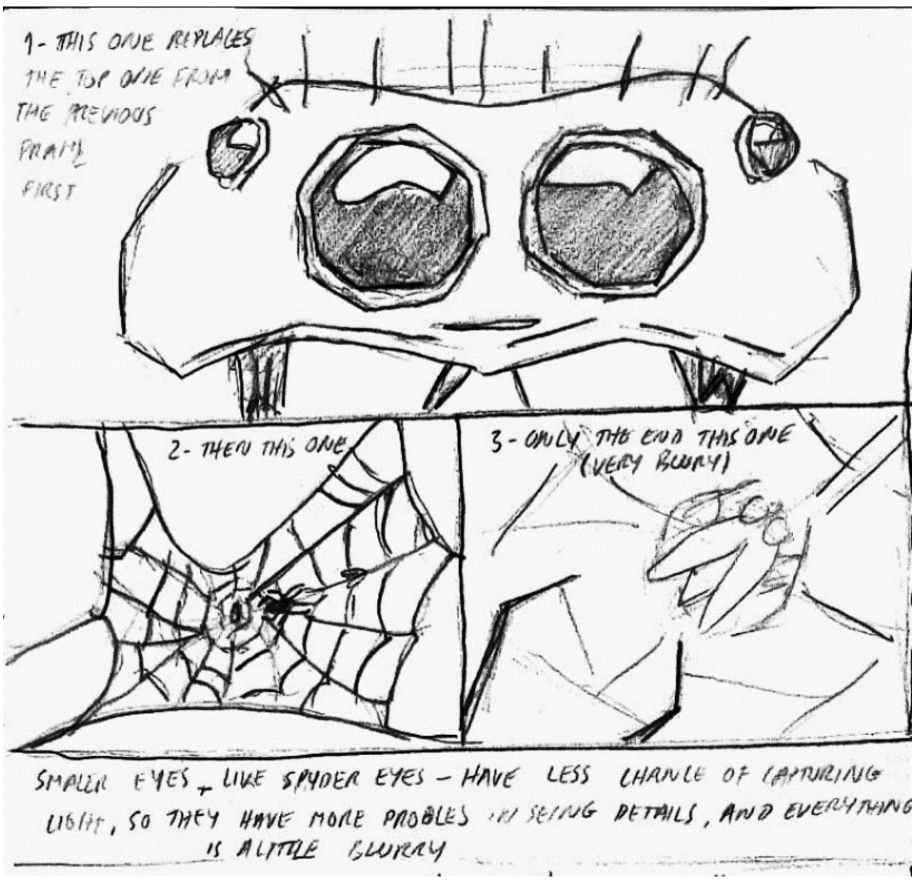

Figure 4. Storyboard panel. Two different components compose each panel: visual and written. The visual component shows the vector illustrations present in each frame of the animation and the written component, which is itself divided in two, describes both the part of the script the represented frames correspond to (bottom component) and the changes of state: motion, opacity, velocity, transition etc. of those illustrations.

Storyboarding is a key part of the animation production process. It is essential to help the creators visualize the ideas and concepts described on the script. Creating the storyboards for #WAWUA episodes required between two and three working days per episode and allowed me to set up a plan for the development of the videos, which included:

1. The elements that need to be design - creating a storyboard required me to think of and developed the best way of illustrating the concepts and ideas written on the script. This included straight forward ideas as Episode's II: *We can't touch the starts, flight trough different galaxies or land on planets outside of our solar system,* (figure 5) that are easily represent by the enumerated elements starts, galaxies and planets. But also, hard to represent concepts as the same episode's: *Building very big telescopes, though, is not only expensive but also difficult and, sometimes, even impossible,* (figure 6) involving more creative and imaginative ways of showing ideas that don't have a direct representation.

Figure 5. Storyboard panel Episode's II script line: *We can't touch the starts, flight trough different galaxies or land on planets outside of our solar system* and screenshot of the correspondent final version on the animation video.

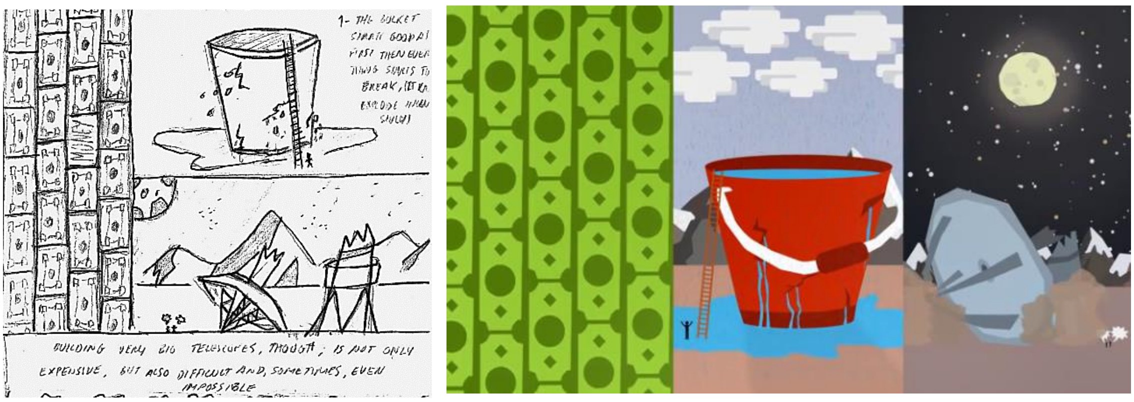

Figure 6. Storyboard panel Episode's II script line: *Building very big telescopes, though, is not only expensive but also difficult and, sometimes, even impossible,* and screenshot of the correspondent final version on the animation video.

2. The layers that compose the graphical elements and the way they need to be laid out – storyboarding is followed by illustration/design and animation. In order to properly design the components to be animated it is important to determine the overall way things move and how they relate to each other.

3. An idea on how the visuals interact with the script – for the episodes it was often necessary to show processes that are hard to portray through words, such as nuclear fusion (Episode III – figure 7) or planet formation (Episode V), and understanding how the illustration of those concepts related to the written script was the key role of the storyboard, allowing adaptations and alterations.

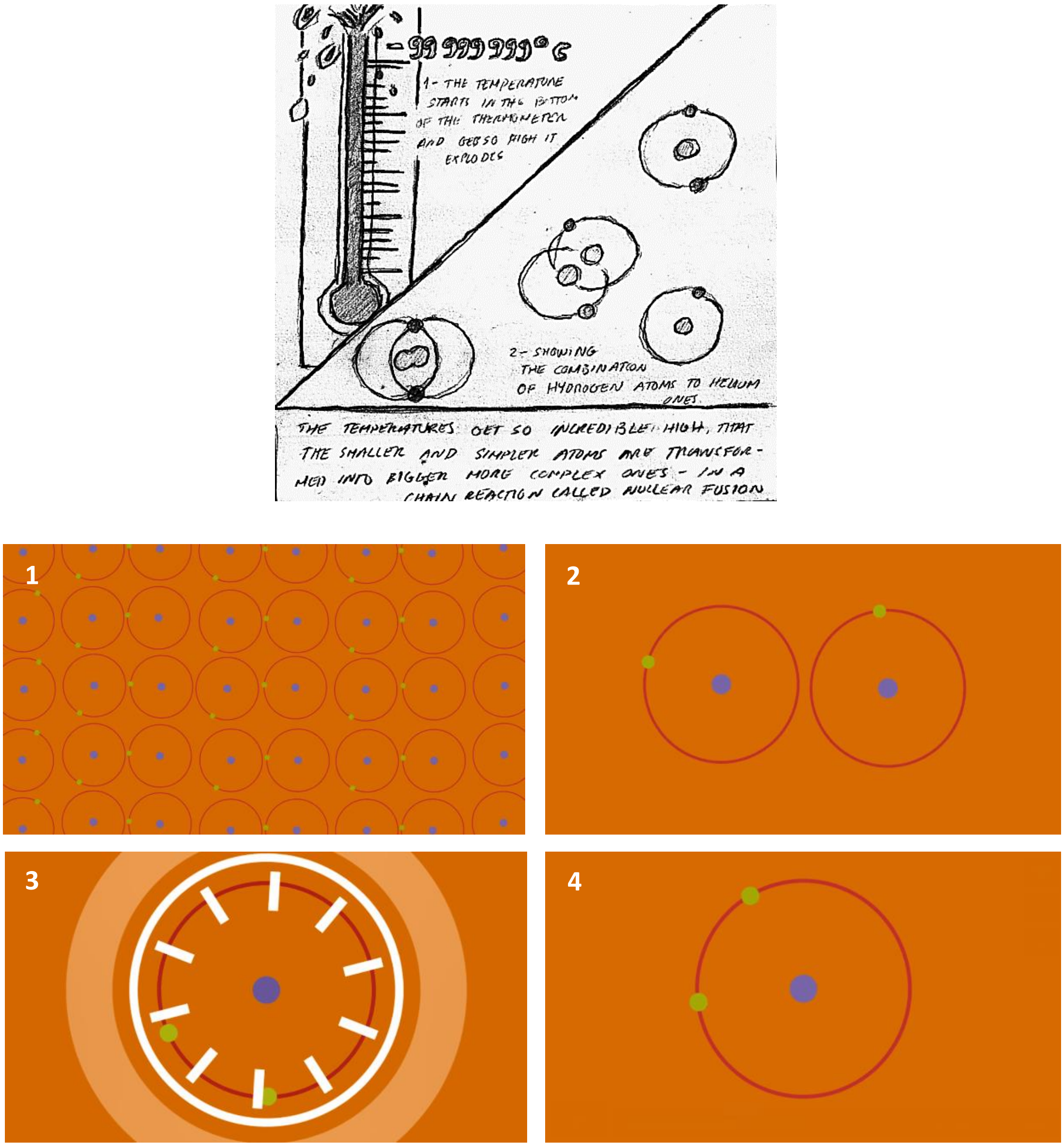

Figure 7. Storyboard panel and respective screenshots of the representation of nuclear fusion in episode III: "We are Stardust!", sequenced from 1 to 4.

Before they were implemented in the animation step the storyboards were, once again, reviewed by the EPO team. The entire set of storyboards for #WAWUA can be found in the attachments (attachments 2.).

III.5.3. VOICE OVER

Each of #WAWUA's episodes followed a single continuous narration that did not involve dialogue. Therefore, the scripts were read and recorded to create a voice-over by a single narrator. The final goal of the project was to have the episodes in both English and Spanish. As so, it was necessary to find off-screen narrators, ideally native speakers, to record voice-overs for both languages.

The necessity of these narrators offered itself has an additional opportunity to involve astronomers and ALMA staff in the production process and simultaneously avoid the cost of hiring an external professional. The narrations where performed by two volunteers: Callum Belhouse, PhD student at the European Southern Observatory (ESO), for the English voice-over and Laura Gómez, Science Archive Content Manager at ALMA, for the Spanish voice-over.

To record the voice-overs a desk microphone, a computer, software (in this case QuickTime) and headphones were used. Previously to the sessions, both narrators reviewed and practice their respective scripts, to avoid problems such as choppy line reading. The sessions themselves took place in a quiet room (limiting extraneous noises), where the narrators read the script into the microphone connected to a computer running the audio-recording software. During the sessions the narrators were given the freedom to show their own interpretation of the script. Emotion, tone, and pitch where mainly decided and chosen by them, with punctual remarks given by me and the EPO team.

In general, the entirety of an individual script was recorded in the same session, as many times as necessary for all the participants to be satisfied with the final result. This prevented the differences in levels, background noise, etc. that can be caused by slightly different set ups from session to session. However, some unclear wording, mistakes and other minor problems where only noticed and made evident during the audio editing process. In those cases, the affected part, or the script in its entirety were re-recorded.

It is important to mention that the English voice over was selected as the guide for cadency and pace for the animation stage, therefore, Laura, as the Spanish voice over narrator, had the added task of not only delivering the voice-over but doing so in a rhythm and cadency that resembled the English version.

The recordings were then edited using Audacity®, a free audio editing software, in a process that included removal of ambient noise, normalization of the volume, compression of the audio signal and slight tone and pitch adjustments. The process was finalized with the creation of an audio file ready to be used in the animation software.

III.5.4. ILLUSTRATION/DESIGN

In #WAWAU the illustrations (a.k.a. graphical elements or vector illustrations) are the "translation" of the sketched storyboards into vectors: digital images that can be scaled infinitely without losing quality. These vectors are the graphical elements animated later on and include everything that composes the visuals of the videos: backgrounds, objects, words, etc.

Consequently, in order to have complete control over all the elements within each graphic component when they reach the animation stage, the vector illustrations had to be created and prepared in a specific way.

Analyzing the storyboard and the descriptions of the motions: entries, exits, transitions and overall movements of the frame's different components is essential to pre-assess the pieces of the designs which needed to be controlled later on in the animation stage. If a part of a component is intended to move independently from another, than it is necessary that it is created in a separate layer. An example of this in #WAWUA are the bee wings in Episode I (figure 8). They were illustrated in layers separate from the bee's body, as they would move autonomously from it. Additionally, because they were beating with a different rotation in the parallel sides of the body, it was necessary to create their vectors in different layers as well, so the rotation movement could be created distinctly;

Figure 8. Sequence of screenshots to illustrate the movement of the bees' wings in episode I: "ALMA sees the invisible".

Throughout the different videos there are occasions where it was important to have control of every single element of an illustration, in others keeping certain elements together was more efficient. Therefore, the designs where first created in the Adobe Illustrator software using graphic pad and then imported into another Adobe software, After Effects, as separated layers which allowed for independent alterations and mobility.

The illustration creation was a time-consuming process, as I was initially unfamiliar with the software, the use of a graphic pad and the process of illustrating digitally for posterior use in animation. Even though most of the vectors where created before the animation process was initiated, the novelty of the process and my inexperience often demanded a back step to the illustrations for layout review, creation of new layers so that previously dependent components became independently controllable or even the design of new assets there were not initially planned for. On average the design of the graphical elements for one episode took between seven and nine working days.

III.5.5. MOTION GRAPHICS/ANIMATION

Animation was the most laborious step of the entire development process. Animating the two-minute episodes required an average of 20 to 25 working days. This was due to both the inherent intricacies of the animation process itself and the learning process involved in creating an animation video with no previous experience.

This stage brings together the results of all previous steps into one common project in Adobe After Effects: (1) the voice-over (created through the script), serving as a time pacer (all assets and movements animated so that they are in harmonic combination and perfect timing with it); (2) the storyboard, working as the motion guide indicating the direction and order of all the movements, changes of condition and transitions, and (3) the vector illustrations, as the pieces coming to life, i.e. From static, unchanging elements to dynamic ones that transform over time (figure 9).

Animation is change over time. It is based on the idea that every object has an initial state or condition that changes over time - it can be its position, shape, color, luminosity, or any other property – to a different form.

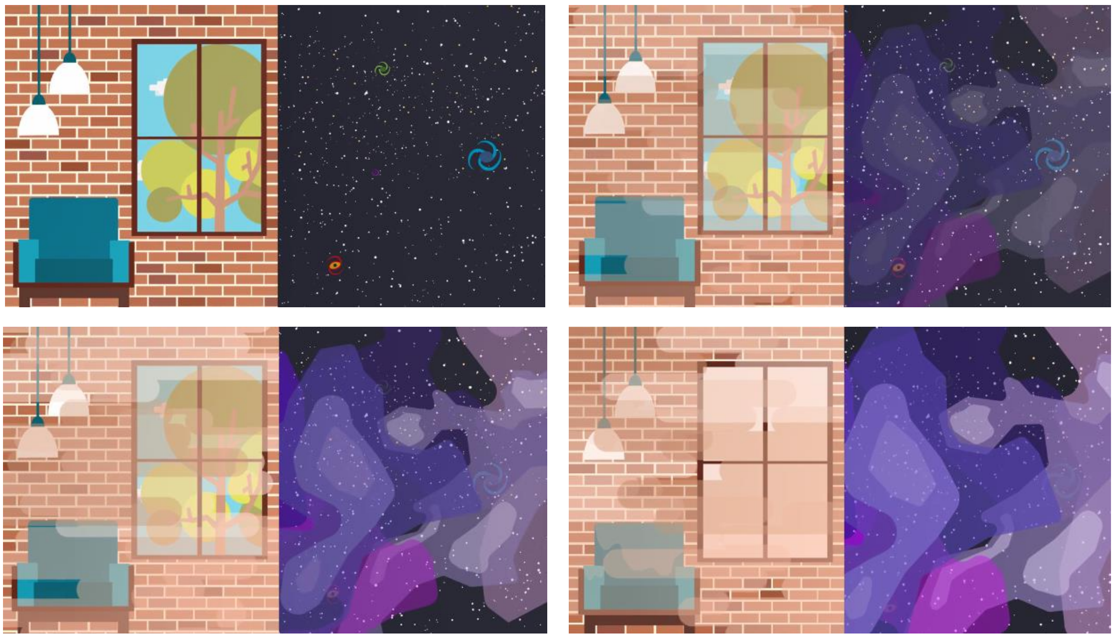

Figure 9. Screenshots that illustrate change over time (animation) in episode V: "ALMA and the Cold Interstellar Clouds".

For the creation of #WAWUA episodes these changes were obtained through keyframing in Adobe After effects. The animator, in this case me, sets key-frames that define the initial state of the object (spatial position, opacity, etc.) and its final state. The values between keyframes are interpolated by the software. Every element is animated key-frame by key-frame so that it moves form one point of the another, fades out, fades in, changes shape, etc. Therefore, the entire animation process relies on establishing the appropriate key-frames to obtain the desired changes through time and it follows an overall hierarchy:

1. First, each layer of a specific graphical element is animated – for example the 4 wings of the bee (which is in this case considered the graphical element) in Episode I where individually animated as mentioned before (figure 8).

2. Second, a graphical element itself is animated relatively to another graphical element or the background – the entire body of the bee was animated to move relatively to the flowers (other graphical element) and the green and flowery background (figure 10);

Figure 10. Sequence of screenshots that show the animation of the central graphical element – the bee – relatively to its background – the flowers – in episode I. Sequence from 1 to 6.

3. Third, the composition obtained from the graphical elements and the background, can be animated relatively to another composition, which is normally called a transition – the composition that depicts the movement of the snake transitions form taking the entire screen, to occupying only half of it, being the other half taken by the bee composition (figure 11).

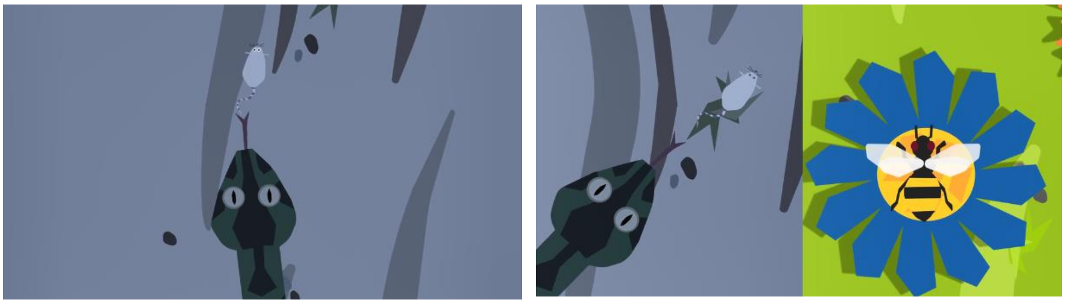

Figure 11. Two different scene screenshots in episode I showing the transition to illustrate the transition between two different compositions compromised of a background and in motion graphical elements.

As stated before, in #WAWUA the voice over used as pacing for the creation of the animations was originally the one in English, therefore, for the creation of the final episodes in Spanish an additional step was necessary to synchronize the animations with the voice-over. Even though the voice-overs were created with the intend of deferring as little as possible, English and Spanish are very distinct languages with inevitable passing differences. The adaptation procedure was a complex one that involved a lot of timing and transition changes.

III.5.6. SOUND EDITING

The audio adjustments, the music and the sound effects are a very crucial part of the process. Music and sound effects are used to set the tone of the video and reinforce the message aimed to be deliver. They also have an important role in provoking different emotions in the viewers.

Finding the balance between the three components of audio: voice-over, music and sound effects is a complex task that took two to three days to complete. The voice-over is crucial for the communication of the message to the audience and it is necessary that it stands out, not drown by the music and sound effects. However, good music and sound effects will reinforce the mood the video, setting its tone, and fortify the message. Therefore, it is necessary that the sound editing guarantees the strength of each element to be maximized.

Selecting the adequate track/music for each episode, even though a somewhat intuitive process, involved the search for one whose pace, flow, tone, and rhythm played in harmony with video, as there was already a narrative being told through images and words with its own pace, flow, and rhythm. Several different tracks where tried against each episode so that the effect of each one could be compared, and the best for the desired effect selected. Because there were copyright considerations to contemplate, and ALMA resources to produce the videos were limited, all the tracks selected where royalty free music.

The sound effects are all the sounds that create the environment of the story being told. They are not only the rain in the background, the squeak of a mouse or the sound of the sea, but also the subtle sounds of motion like swooshes and hits that accompany visual movements or transitions. There are an infinite variety of these types of sounds and a selection was created with royalty free sound effects to be used in #WAWUA episodes. The viewer is often unaware of these sounds, which is the main goal of good sound editing, they bring a layer of depth to the animation, enhancing and complementing the editing style without being distracting.

The general rules for sound editing focus on having music on a low level whenever there is narration, so that the voices can be clearly heard; make sure the sound effects are heard over the background music track and finally, guarantee that the overall combination of both effects and music is not distracting the viewer form the main narration.

Creating the 5 episodes that form #WAWUA ("Why do Astronomers Want to Use ALMA?") was a long and well though process that revealed itself as a great challenge. After defining the purpose of project, understand the messages we aimed to transmit and finding the better format to reach the target audiences, it was still necessary to create the videos themselves for scratch. Not only was it my first contact with the software necessary to create an animation (Adobe Illustrator and Adobe After Effects), but also the first contact with the entire production process itself. Each of the 6 described steps was essential to obtain the final result and the support of ALMA's EPO team and ALMA staff in every stage was crucial: they offered suggestions, constructive criticism and expertise during the script writing and storyboarding process, offered their voices as the narrators of the story, and shared their knowledge and skill to teach me how to create vector illustrations, animate those vectors and create a video. As my internship was coming to an end, ALMA EPO team refined and enhanced the videos, and later on made them public.

PART IV

ANIMATION RECEPTION

The publication of the videos was made through a variety of channels: social media, outreach activities, ALMA website and through traditional media. Part IV consists of a brief description of the different platforms selected to disseminate the videos, followed by an analysis of the reception of those videos on ALMA's most used and followed social media – Facebook. Additionally, the main lessons learnt during the entire duration of the internship, including the process of creating the series and the teachings attained through their publication in social media, will be addressed. Hopefully, assessing the relevance of the good practices gathered before the beginning of the project and adding some new insights to the list.

IV.1. DISSEMINATION STRATEGIES

To reach the initially defined target audiences, the videos where distributed in a variety of platforms, being their dissemination done both online and through other non-internet related channels.

The online distribution relied not only on ALMA own channels: (1) ALMA website and its version for kids, ALMA kids, (2) ALMA social media channels including Facebook, Twitter, Instagram, (3) ALMA video platforms: YouTube and Vimeo; but also, the partners online portals, including ESO's, JAO's and NRAO websites. The episodes were adapted to become "ESOcasts", the video podcast series created by the European Southern Observatory to report the latest news and research from the institution. Additionally, the distribution was promoted through a series of releases in the online version of some Chilean media outlets such as newspapers, TV channels and magazines, including: LaTrecera, TVN, VTR (see attachments 3.) and their respective social media, including YouTube channels, Twitter accounts and similar means.

The dissemination made via other non-internet related channels included the integration of the series in ALMA outreach activities and expositions, two examples are (1) the exposition now present in one of the metro stations in Santiago de Chile, (2) ALMA open day. The series is also available in one of Chile's TV operaters – VTR – and its regional channels (Arica TV, Calama TV, VIVE Chile Elqui, Quintavisión, Sextavisión, TV8, Vértice TV, ATV Valdivia), as well as in its Video on Deman (VOD) option. And was presented in printed versions of Chilean traditional media, such as in the newspaper Las Ultimas Noticias (LUN).

This report, and the following analysis of the reception of the series, will focus on ALMA's Facebook pages: the English version "ALMA Observatory" and the Spanish version "Observatorio ALMA". The option to select this platform as the object of the following analysis was based on the fact that, out of all the online and social media platforms ALMA is active on, these are the ones with the biggest number of followers/likes.

Additionally, Facebook business pages offer a series of statistical data that allows the study of the performance of the page through different metrics, including video related metrics, such as tracking audience retention. Those metrics will be used in the analysis that follows as a way of measuring the impact of #WAWUA and give new insight in how the process of creation can be modified to fit the viewer's needs.

IV.2. THE STATISTICS

IV.2.1. PAGES' CHARACTERIZATION

ALMA owns two Facebook pages, directed towards two different (even though not mutually exclusive) audiences. A page in English – "ALMA Observatory" – directed towards a more global audience and a page in Spanish – "Observatorio ALMA" – aimed at ALMA's vast Spanish speaking audience in South America, especially in Chile.

As of the 8th of March 2018, "ALMA Observatory" totaled 20 087 followers. "Observatorio ALMA" counted with a slightly superior number of followers with 20 991. The demographics of the followers of both pages, however, is considerably different. While the Spanish version has an audience where both genders are roughly equally represented – 48% of the followers are female and 52% male –, in the English version, approximately two thirds of the followers are male (66%) with only a third of them being female (34%). Nevertheless, the most significant audience, in both cases, is composed of those between 18 and 34 years old. It accounts for 64% of all the views in the Spanish page and 54% in the English version (Figure 12).

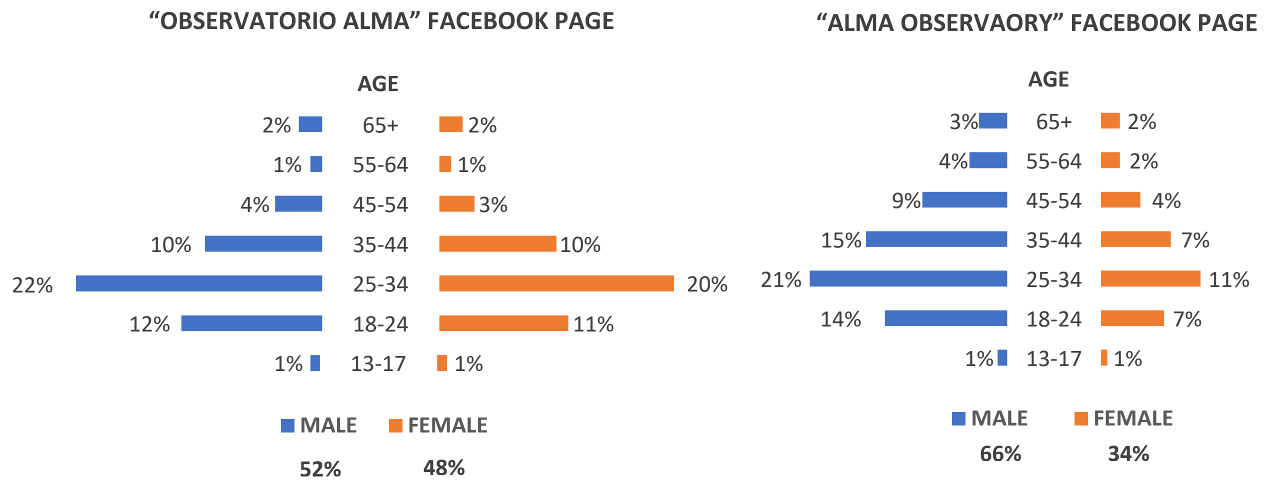

Figure 12. Age structure of the followers of ALMA’s Facebook pages. First, on the left, the Spanish version – “Observatorio ALMA”. Second, on the right, the English version – “ALMA Observatory”.

In the Spanish version, a majority of the followers is located in Chile, accounting for 60% of the total of followers, followed by those in Mexico, who compromise 14%. In third, fourth and fifth place come those in Argentina, Colombia, and Peru, accounting together for approximately 10% of all followers. The English page has, as expected, a more homogenous country representation with four different countries with more than a thousand subscribers each. It is once again topped by Chile, which compromise roughly 19% of all followers, followed by the United States of America, Brazil, and India, accounting for 14%, 8% and 5% respectively (Table 2).

Amongst the total of followers (combining the data from both pages), Spanish is the most spoken language with 75% of those following “Observatorio ALMA” speaking it and another 25% of those following “ALMA Observatory”. However, English is the top language in “ALMA Observatory” totaling 30% of the users. Portuguese comes in as the third in the rank in both pages after English and Spanish.

Table 2. Number of followers on the top five countries of both the English and Spanish versions of ALMA’s Facebook page. Data collected on March 8th, 2018.

“OBSERVATORIO ALMA” FACEBOOK (ES)	
COUNTRY	**FOLLOWERS**
Chile	12 592
Mexico	3 030
Argentina	925
Colombia	642
Peru	545

“ALMA OBSERVATORY” FACEBOOK (EN)	
COUNTRY	**FOLLOWERS**
Chile	3 821
United States of America	2 818
Brazil	1 698
India	1 019
Italy	994

IV.2.2. #WAWUA IN SPANISH

Table 3. Permanent links connecting with the episodes online voiced over in Spanish on both their permanent location on Facebook and on ALMA website.

EPISODE	FACEBOOK PERMANENT LINK	WEBSITE PERMANENT LINK (ES)
I	https://www.facebook.com/ObservatorioALMA/videos/1557391974323375/	http://www.almaobservatory.org/es/extension/por-que-los-astronomos-quieren-usar-alma/
II	https://www.facebook.com/ObservatorioALMA/videos/1563599790369260/	
III	https://www.facebook.com/ObservatorioALMA/videos/1570086253053947/	
IV	https://www.facebook.com/ObservatorioALMA/videos/1576646319064607/	
V	https://www.facebook.com/ObservatorioALMA/videos/1582811441781428/	

#WAWUA episodes were released on the Spanish version of ALMA's Facebook page one by one, every Thursday of the month of September 2017, either at 17:15h or 17:30h local time in Chile. The last of the episodes, episode IV: "ALMA y las frías nubes interestelares", was published on the first Thursday of the following month, the 5th of October 2017. The choice to publish on both Thursday and on those specific schedules fell on the fact that this is when "Observatorio ALMA" followers are most active. Therefore, that is the best schedule to maximize the number of people reached.

The videos where all posted with the Spanish voice over and followed the same post format: the animation as a native Facebook video, a small introduction that includes the name of the episode, an invitation to download the video. They were always published with the hashtag #WAWUA, that is both an acronym for "Why do Astronomers want to use ALMA?" and a homophone to the word "wáwa" or "guagua" which, in Chilean Spanish, means toddler. The wordplay was an attempt to make the name of the series more memorable for ALMA's Chilean audience (See attachment 4.1).

Since the inaugural debut of the five animated videos, some of them have been republished in posterior dates, however, only the five original posts will be considered in this analysis.

By the 8th of March 2018, the videos together had received over 70 000 views. Facebook algorithms count as views every occasion where the video was clicked to be played or auto-played for 3 seconds or more. This kind of views will, from now on, be addressed as *overall views*. The highest viewed animated video was episode III: "Somos Puelvo de Estrellas!" (figure 13) with close to 40 000 views. It became the most view video in the page since its creation. Episode I: "ALMA Observa lo Invisible" comes in second place counting 17 761 views, followed by Episode IV: "ALMA es una máquina del Tiempo" with roughly 11 000 views. Episodes II: "ALMA es Tecnología de Punta" and V: "ALMA y las Frías Nubes Interestelares" were viewed 2 356 and 667 times, respectively (Table 4).

Figure 13. Screenshot from episode III: "Somos Puelvo de Estrellas!".

Table 4. Statistical data for the 5 #WAWUA episodes published in the "Observatorio ALMA" Facebook page. Data collected on March 8th, 2018.

VIDEO POST	REACH[1]	OVERALL VIEWS[2]	10 SECOND VIEWS (% OF THE ORIGINAL VIEWS)	30 SECOND VIEWS[3] (% OF THE ORIGINAL VIEWS)	95% VIEWS[4] (% OF THE ORIGINAL VIEWS)	COMMENTS	REACTIONS[5]	SHARES
Episode I: "ALMA Observa lo Invisible"	75 865	17 761	7 020 (40%)	4 066 (23%)	1 934 (11%)	12	208	261
Episode II: "ALMA es tecnologia de Punta"	9 822	2 356	861 (37%)	424 (18%)	396 (17%)	6	145	63
Episode III: "¡Somos Puelvo de Estrellas!"	157 625	39 520	15 238 (39%)	8 810 (22%)	4 419 (11%)	40	475	1 300
Episode IV: "¡ALMA es una máquina del Tiempo!"	42 167	10 976	4 555 (42%)	2 886 (26%)	1 636 (15%)	2	109	202
Episode V: "ALMA y las Frías Nubes Interrestelares"	3 230	667	234 (35%)	127 (19%)	126 (19%)	1	44	15

1 Number of unique users (Fans or non-Fans) who saw your Page post in News Feed, Ticker or on your Page.
2 Number of times users watched the videos for more than 3 seconds.
3 Number of times the video was viewed for at least 30 seconds.
4 Number of times the video was watched at 95% of its length, including watches that skipped to this point.
5 Number of people who reacted to a post using one of the 6 reactions: Like, Love, Haha, Wow, Sad, and Angry.

However, a more accurate way of perceiving the engagement of the audience with the videos is to evaluate the number of users who viewed at least 10 seconds of the episodes, those who continued until they reached 30 seconds and eventually those who watched 95% of the video, which will, for the purpose of this analysis, be considered as a full watch.

After ten seconds of video most episodes had lost between 59% and 65% of their initial viewers. Episode IV had the biggest percentage of audience retention (42%) and episode V the lowest (35%) (Figures 14 to 18). The window between the 3-second mark and the 10-second one is the period with the biggest relative drop in audience within all the time windows. As in the second period – 10 to 30 seconds – the biggest relative drop is 51% for episode II, where only this percentage of the users watching at 10 seconds remained until the 30-second mark. In the third and last period – 30 seconds to the end – the most considerable fall accounts for a loss of 52% of those watching at 30 seconds by the end of the animations, and was registered by episode I.

At the 30-second mark, even though episode III is still the most viewed of the five in absolute numbers. Episode IV: “¡ALMA es una máquina del Tiempo!” is the one that shows, as it did in the 10 second mark, a better relative engagement of the audience with the animation. Comparing to the other videos (ex: episode III with 22%) a greater number of the viewers who started watching (26%), kept on doing so until they reached the 30-second mark (Table 4).

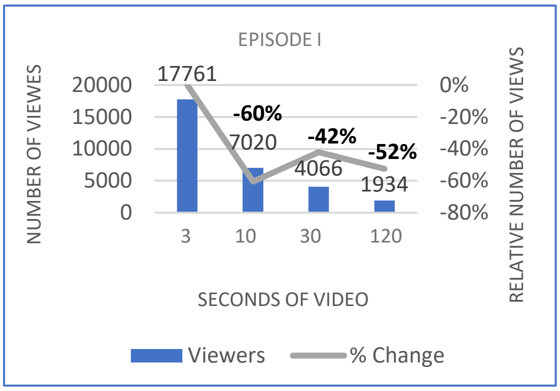

Figure 14. Variation in the number of viewers throughout time marks (3, 10, 30 and 120 seconds(end)) in episode I on “Observatorio ALMA” and relative number of those viewers lost from one time mark to the next.

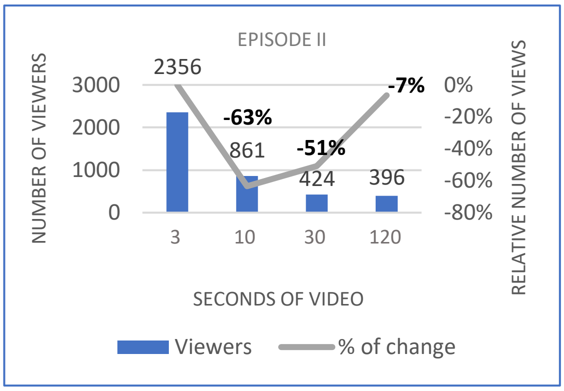

Figure 15. Variation of the number of viewers throughout time marks (3, 10, 30 and 120 seconds(end)) in episode II on “Observatorio ALMA” and relative number of those viewers lost from one time mark to the next.

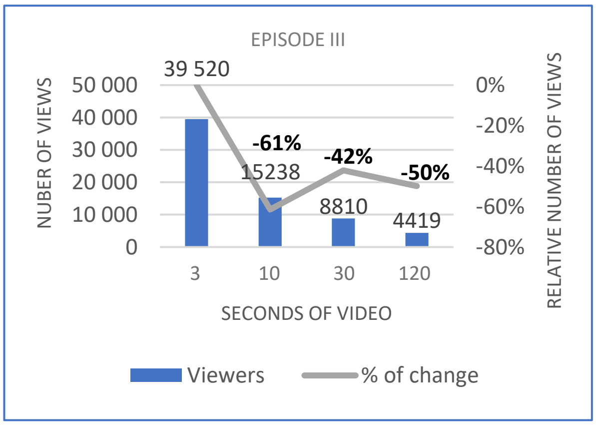

Figure 16. Variation of the number of viewers throughout time marks (3, 10, 30 and 120 seconds(end)) in episode III on “Observatorio ALMA” and relative number of those viewers lost from one time mark to the next.

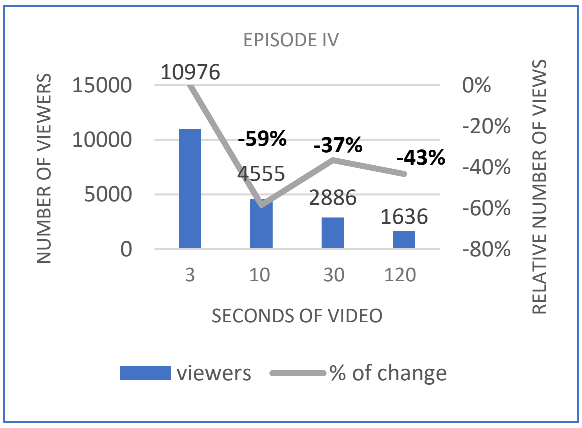

Figure 17. Variation of the number of viewers throughout time marks (3, 10, 30 and 120 seconds(end)) in episode IV on “Observatorio ALMA” and relative number of those viewers lost from one time mark to the next.

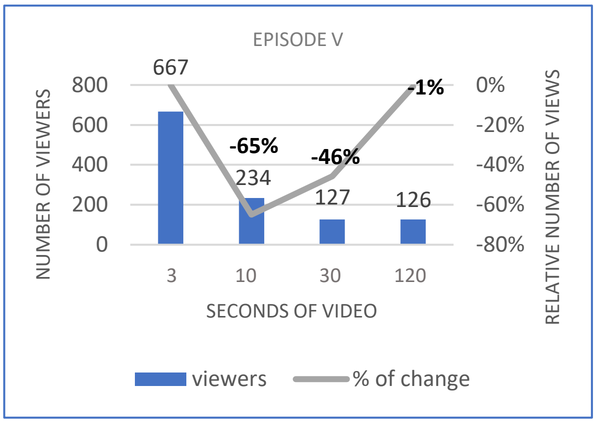

Figure 18. Variation of the number of viewers throughout time marks (3, 10, 30 and 120 seconds(end)) in episode V on "Observatorio ALMA" and relative number of those viewers lost from one time mark to the next.

The video that performed the least in absolute terms was episode V: "ALMA y las Frías Nubes Interrestelares", however it is not the one which showed the least engagement with the viewers who started watching. At the 30-second mark episode II: "ALMA es tecnologia de Punta" is the worst performer with only 18% of its audience viewing for 30 seconds or more.

On average, only 39% of the overall views of #WAWUA episodes had a duration of at least 10 second, and the value drops to 23% when considering the 30-second mark. Meaning that more than half of the audience stopped watching before the 10 seconds were reached and four fifths of it stopped before they reach 30 seconds. For the views that lasted 95% of the complete animations, considered the full duration of the video for the effect of this report, solely 12% of those who started ended up finishing.

When it comes to the number of times the video was watched at 95% of its length, Episode III is still in the leadership in absolute numbers, with almost 5 500 views. Nevertheless, that corresponds to only 11% of those who started viewing the video in the first place. The videos with the weakest performances in absolute terms, episodes II and V, were indeed the ones where audience engagement at 30 seconds was the lowest. Surprisingly however, almost the totality of those who watched the two animations until that time mark, stayed and watched it through, as respectively 93% and 99% percent of those who watched the episodes for 30 seconds, watched the video in its totality (Figure 15 and 18).

Additionally, and when considering how the overall viewers experienced the videos, only episode IV was watched a majority of the times with its respective sound on (56% sound on, 44% sound off), while the other four where viewed mostly with no sound. An overall average of 55% of the views for the five episodes was done with the sound off (Figure 19). Episode V alone was watched more than two thirds of the time with the sound off (70% sound off, 30% sound on). However, when analyzing the same metric in the 10-second mark the values invert and, on average, there was a greater number of views done with sound (64%), even though there was still a considerable number of soundless views (36%) (Figure 20).

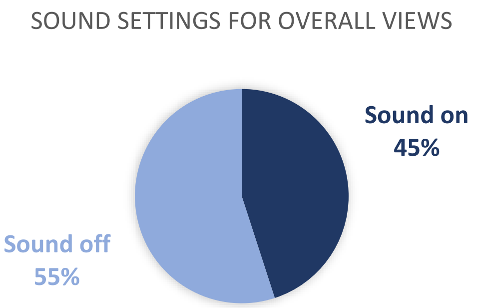

Figure 19. Percentage of overall views of #WAWUA episodes on "Observatorio ALMA" that were done with the sound On and with the sound Off.

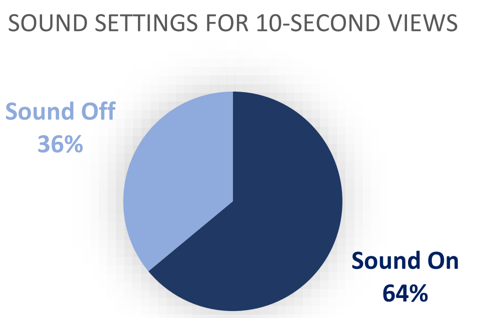

Figure 20. Percentage of at least 10-second views of #WAWUA episodes on "Observatorio ALMA" that were done with the sound On and with the sound Off.

The way the publication of the videos affected the number of overall followers of the page is an important measure of the success of their release. Between the 31st of May 2017 and the 8 of March 2018 the page grew from 11 962 to 16 291 followers. Within this period, the window of publication of the #WAWUA episodes – between the 7th of September 2017 and the 5th of October 2017 – coincides with the biggest growth registered in a 30-day period. During that period, the page got 1 981 new followers (Figure 21).

The day of biggest increase in followers – 431 new followers in a single day – was registered right after the publication of Episode III: "Somos Puelvo de Estrellas", the most successful episode of the animation series. The day of the publication and the three days that follow are the window of greatest growth (from the 21st to 24th of September 2017).

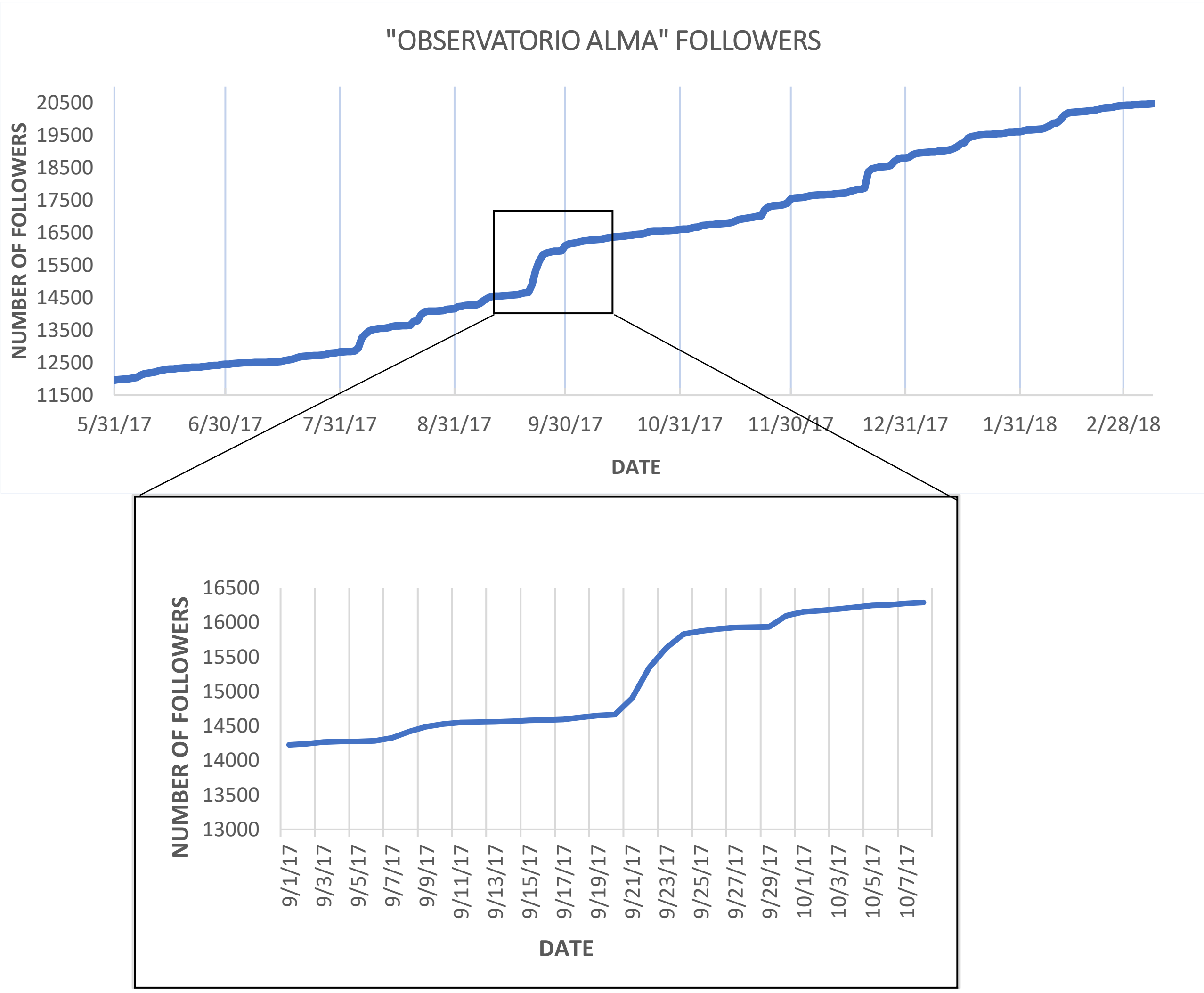

Figure 21. Variation in the lifetime number of followers in "Observatorio ALMA" Facebook page. Data collected on March 8th, 2018.

The prevalent audience of #WAWUA episodes in "Observatorio ALMA" were male users between the ages of 18 and 34 years old. Being those between the ages of 25 and 34 the number one audience of all five episodes individually.

IV.2.3. #WAWUA IN ENGLISH

Table 5. Permanent links connecting to the episodes online voiced over in English on both their permanent location on Facebook and on ALMA website.

EPISODE	FACEBOOK PERMANENT LINK	WEBSITE PERMANENT LINK (ES)
I	https://www.facebook.com/ALMA.Radiotelescope/videos/1678350628842703/	http://www.almaobservatory.org/en/outreach/why-astronomers-want-to-use-alma/
II	https://www.facebook.com/ALMA.Radiotelescope/videos/1684861758191590/	
III	https://www.facebook.com/ALMA.Radiotelescope/videos/1691719914172441/	
IV	https://www.facebook.com/ALMA.Radiotelescope/videos/1698268870184212/	
V	https://www.facebook.com/ALMA.Radiotelescope/videos/1705010552843377/	

The publication of the videos in "ALMA Observatory", the English version of ALMA's Facebook page, followed the same guidelines as its Spanish counterpart. (See attachment 4.2) #WAWUA was released episode by episode every Thursday of the month of September, on the 7th, 14th, 21st and 28th of the month, with the last episode having its debut on the 5th of October 2017. The choice of releasing the videos on Thursdays was once again a pondered one, accounting for the fact that it is the day in which the followers are most active. However, because "ALMA Observatory page" has a more diverse and globally distributed audience, the posts were released at 11:15h and 11:30h CLST (Chilean Summer Time), which is not an ideal release time for the followers in different parts of the world, including the United Stated, India, Brazil and Italy (Table 2), but was the best publishing time according to previous analysis off followers behavior.

Only the first publication of the videos, not their re-post, will be considered for this overall study. The reach of #WAWUA in "ALMA Observatory", with the animations voiced over in English, was considerably lower than that of the Spanish version. Overall, the series gathered 8 110 views. Only 12% of those verified in the Spanish counterpart.

The most view episode is episode I: “ALMA sees the invisible” (figure 22) with a total of 3 587 overall (3 seconds or more). It is the episode with the biggest number of absolute views in every time mark: 1 551 ten-second views, 745 thirty-second and 286 full views. Followed by episode III: “We are stardust!” and episode II: “ALMA is State of the Art Technology”, with very similar performances. The first gathered a total of 1 465 overall views, 555 ten-second view, 248 thirty-second views and 103 complete views and the second, in the same order, 1 398, 502, 211 and 90 views. The video with the lowest performance, as what happened in “Observatorio ALMA”, was episode V: “ALMA and the Cold Interstellar Clouds”, with only 667 views, of which 255 lasted 10 seconds of more, 97 lasted at least thirty seconds and only 44 lasted for the entire duration of the video (Table 6).

Figure 22. Screenshot from episode I*:* “ALMA sees the invisible”.

Table 6. Statistical data for the 5 #WAWUA episodes published in the "ALMA Observatory" Facebook page. Data collected on March 8th, 2018.

VIDEO POST	REACH[1]	VIEWS[2]	10 SECOND VIEWS (% OF THE ORIGINAL VIEWS)	30 SECOND VIEWS[3] (% OF THE ORIGINAL VIEWS)	95% VIEWS[4] (% OF THE ORIGINAL VIEWS)	COMMENTS	REACTIONS[4]	SHARES
Episode I: "ALMA Observes the Invisible"	13 178	3 587	1 551 (43%)	745 (21%)	286 (8%)	4	152	72
Episode II: "ALMA is State of the Art Technology"	5 308	1 398	502 (36%)	211 (15%)	90 (6%)	2	76	37
Episode III: "We are Stardust!"	6 261	1 465	555 (38%)	248 (17%)	103 (7%)	1	106	37
Episode IV: "ALMA is a Time Machine!"	3 240	928	350 (38%)	148 (16%)	64 (7%)	0	67	17
Episode V: "ALMA and the Cold Interstellar Clouds"	3 230	667	255 (38%)	97 (15%)	44 (7%)	0	40	6

[1] Number of unique users (Fans or non-Fans) who saw your Page post in News Feed, Ticker or on your Page.

[2] Number of times users watched the videos for more than 3 seconds.

[3] Number of times the video was viewed for at least 30 seconds.

[4] Number of times the video was watched at 95% of its length, including watches that skipped to this point.

[5] Number of people who reacted to a post using one of the 6 reactions: Like, Love, Haha, Wow, Sad, and Angry.

The engagement of the audience throughout the videos was more homogenous and predictable than that of the Spanish version. With the exception of episode I, where the drop from the 3-second mark to the 10 second one was less than 60% (57%), all other cases experienced a fall on views of over 60%. Roughly 37% of those who watched 3 seconds of episodes II, III, IV and V continued watching until the 10 second mark, and only 18% of those continued watching to the 30-seconds mark. An average of 7% of the views of the four episodes was complete (Figures 23 to 26). Episode I, which experienced smaller relative falls in the first to time frames (3 to 10-second, and 10 to 30-second marks) experienced a bigger relative drop (62%) in the 30-second to end window, making so that, only 8% of the viewers watched the complete animation (Figure 23 and table 6).

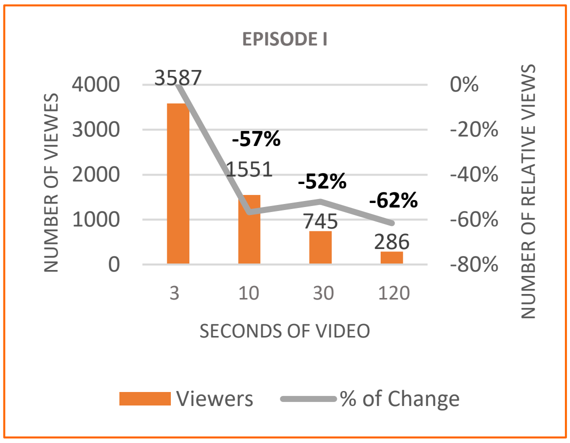

Figure 23. Variation of the number of viewers throughout time marks (3, 10, 30 and 120 seconds(end)) in episode I on "ALMA Observatory" and relative number of those viewers lost from one time mark to the next.

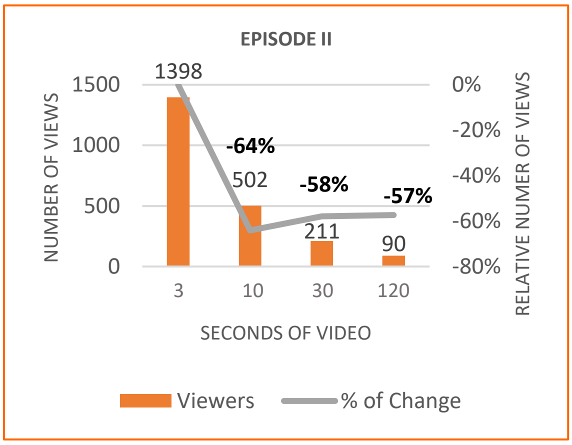

Figure 24. Variation of the number of viewers throughout time marks (3, 10, 30 and 120 seconds(end)) in episode II on "ALMA Observatory" and relative number of those viewers lost from one time mark to the next

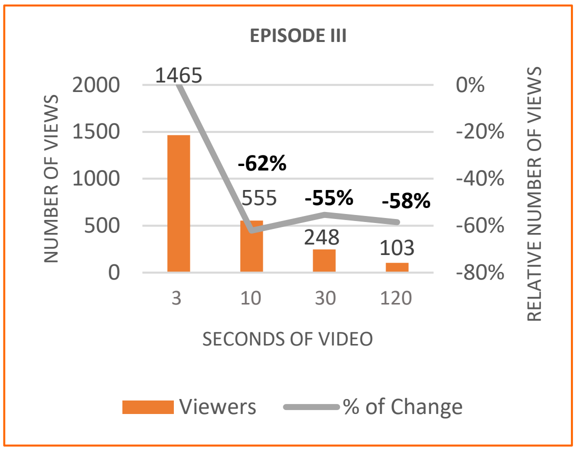

Figure 25. Variation of the number of viewers throughout time marks (3, 10, 30 and 120 seconds(end)) in episode III on "ALMA Observatory" and relative number of those viewers lost from one time mark to the next.

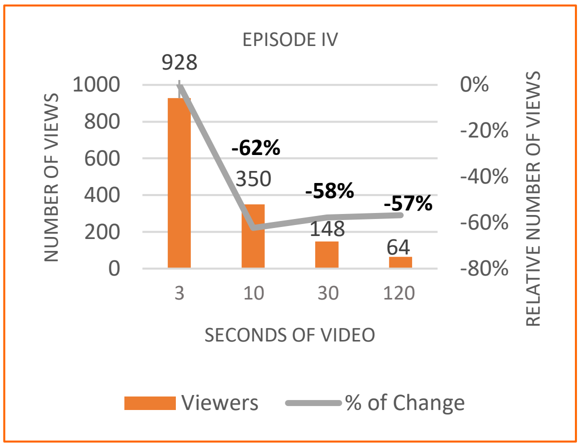

Figure 26. Variation of the number of viewers throughout time marks (3, 10, 30 and 120 seconds(end)) in episode IV on "ALMA Observatory" and relative number of those viewers lost from one time mark to the next

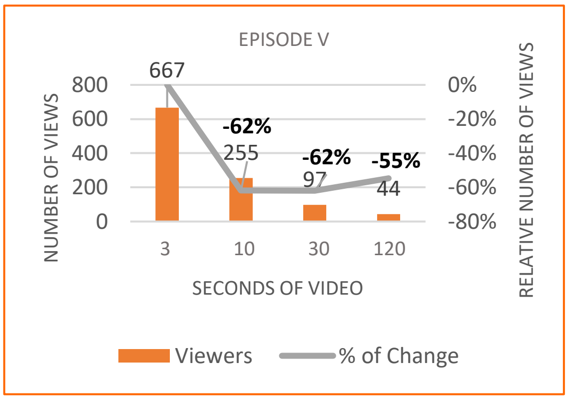

Figure 27. Variation of the number of viewers throughout time marks (3, 10, 30 and 120 seconds(end)) in episode V on "ALMA Observatory" and relative number of those viewers lost from one time mark to the next

Unlike what happened with episodes II and V in “Observatorio ALMA”, where almost 100% of the views with 30 seconds of duration transformed into full views. All the episodes of #WAWUA released in “ALMA Observatory” experienced a continuous drop of over 50% in every time mark (Figures 23 to 27).

Regarding the sound settings: almost 80% of all overall views where done with the sound off (Figure 28). And even though there was a rise in the number of views done with the sound on in the views that lasted 10 seconds or more, their relative number was still inferior to that of the no sound views: 37% against 63% (Figure 29).

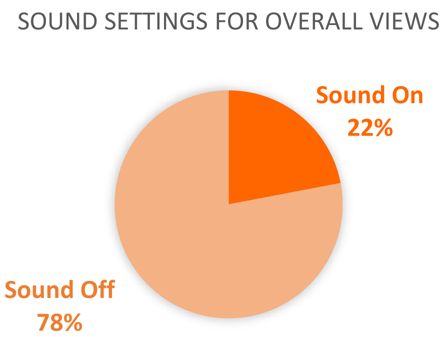

Figure 28. Percentage of overall views of #WAWUA episodes on “ALMA Observatory” that were done with the sound On and with the sound Off.

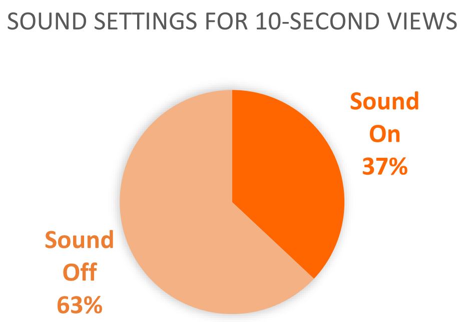

Figure 29. Percentage of at least 10-second views of #WAWUA episodes on “ALMA Observatory” that were done with the sound On and with the sound Off.

The number of lifetime followers/likes in “ALMA Observatory” Facebook page has been steadily increasing. From roughly 14 000 on the 31st of May 2017 to the 20 087 registered on 8th of March 2018. However, and unlike what succeeded in the Spanish version of the page, there is no observable effect in the counting linked to the debut of the videos. Between September 7th, 2017 and October 5th, 2017, 497 new users followed/liked “ALMA Observatory”, showing a considerably slower rate of growth than its Spanish counterpart in the period of #WAWUAS release (Figure 30).

The top overall audience of the episodes was compromised of those between the ages of 18 and 34 once again. However, and unlike what happen in the “Observatorio ALMA” page, there is more variety in the gender on the top audience of the individual episodes, with both male and female users coming on top in different videos. The most prevalent audience of Episode I and III were women between the ages of 18 and 24, while episode II, IV and V had a main audience of man: 25 to 34 years old in the first two cases and 35 to 44 years old in the last.

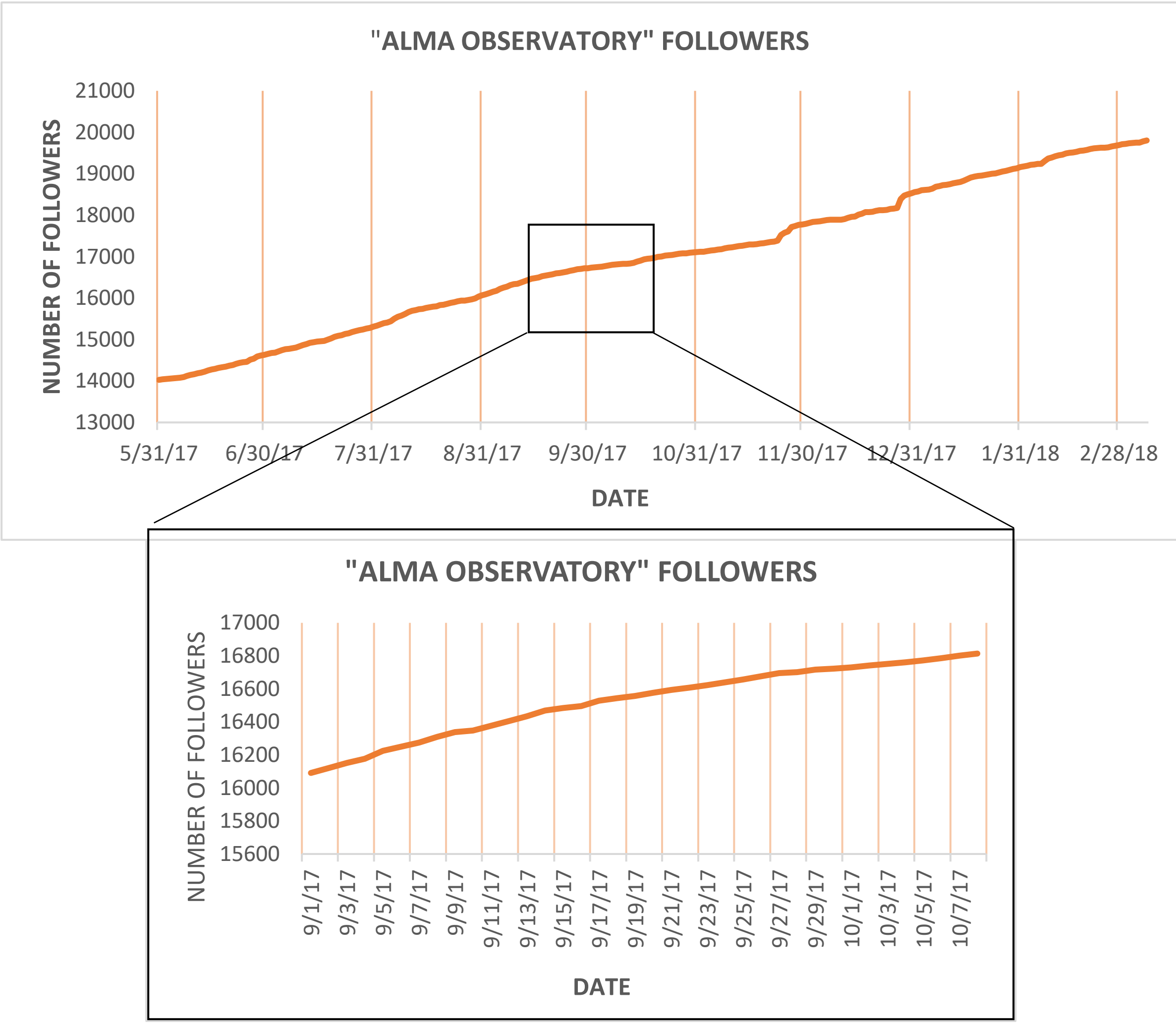

Figure 30. Variation in the lifetime number of followers in “ALMA Observatory” Facebook page. Data collected on March 8th, 2018.

PART V

LESSONS LEARNT

Finally, part V of this report, is intended to gather the main lessons learnt during the different parts and dimensions of my internship at ALMA's EPO. From the specifics of all the things learnt through the publication of #WAWUA on social media, to the wider view of the teachings and experiences collected by working in a multinational and multiorganizational institution like ALMA.

V.1. BY ANALYZING THE RECEPTION OF #WAWUA IN SOCIAL MEDIA

The publication of the series of 5 episodes in social media, and the analysis made of its impact on both Facebook pages of ALMA, was an opportunity for great learning. There are of course limitations with the analysis done, no claim is being made regarding the generalization of these results and no statistical inference is intended with a sample size of 5 videos. Nevertheless, some of the observations done provide endorsement to several of the best-practices collected during the first phase of the project and align with the results of current research. Others are worth taking a note of and may the base for further research. Here is a collection of the learnt lessons:

- **Online videos, and in particular animation videos, have the potential to reach thousands of viewers and are, indeed, a powerful tool for the science outreach of international institutions like ALMA.** A series of observations supports this idea:
  - The almost 80 000 thousand views received by #WUAWA in its debut on Facebook alone show the true potential of both online video and animation video as channels to communicate ALMA's science and the institution on social media.
  - 3 of the 5 most viewed videos in the Spanish version of ALMA's Facebook page were #WAWUA episodes and the top position is occupied by episode III: "We are stardust!" with more than 39 000 views, which is, by itself, more than the roughly 21 000 followers of the page. Meaning that the video spread beyond ALMA's closest community of followers and is a good indication of a wider audience being reached.

- The more accentuated growth in the lifetime number of followers occurring during the period of publication of the #WAUWA in “Observatorio ALMA” – 2000 new followers in a month – is evidence of how the series generated more interest in the page of the organization and widen ALMA’s direct audience.
- The high engagement of the viewers with the videos, demonstrated by the high number of those who reacted, commented, and specially shared, is a strong indicator that the videos and their content resonated with the audience. After all, users would only share content that they considered interesting or useful.

- **The publication of the videos promoted, as pointed by previous research (Kent, 2015, Babu and Gopalaswamy, 2011, Welbourn, 2016**), **the participation and interaction with the audience.**
  - A considerable number of users not only saw the videos but also interacted with them, by reacting, commenting, and sharing the video. They were active participants of the communication initiative and used comments to ask questions, initiate debates and indicate the video as a reliable source of information to other users, fostering the interaction between ALMA and its audience.

    This kind of interaction promotes the two-way exchange that is now deemed essential by several authors (ex: Bultitude,2011; Hetland, 2014), to encourage a change of attitude in the public towards science and is the new paradigm in the landscape of science communication.

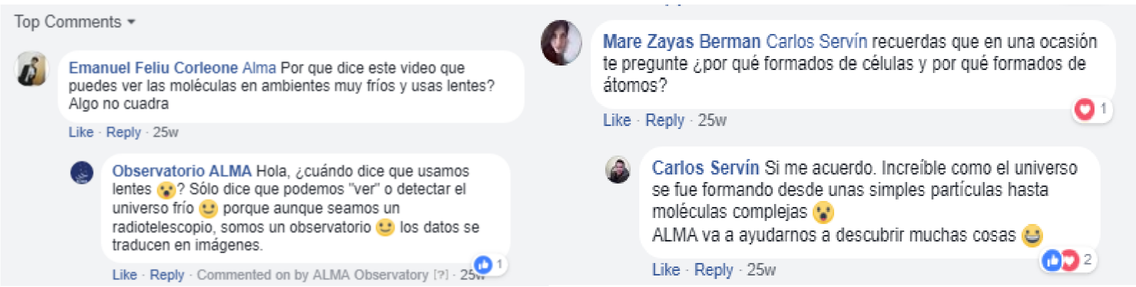

Figure 31. Examples of comments in episode III, posted in “Observatorio ALMA” that ask question and promote interaction. On the left, a user asks: *Alma why does this video say that one can see the molecules in very cold environments and uses lenses? Something doesn’t make sense.* On the right: *Carlos Servin, do you remember when I asked you: why where we made of cells and why cells where made of atoms?.*

- **The videos showed to be, as indicated by Erviti and Stengler (2016), a particularly good tool to reach those born after 1980.**
    - With the top audience of all videos in both the Spanish and English, with exception of one (episode V in its English version), being composed by those either between 18 and 24 years of age (born between 1994 and 2000) or 25 to 34 years of age (born between 1984 and 1993), the series has showed itself to be an important channel to disseminate the science behind ALMA to this specific audience, which is already accustomed to and particularly enthusiast of visual online communication.

- **Most of those who start watching click out in the first 10 seconds of the video. This suggests that changing those first ten seconds could be a good way of engaging more viewers.**
    - As an overall trend in all the animations published, more than half of the viewers who start watching click out in the first 10 seconds of video, and the number continues to drop with each passing time mark: by 30 seconds only between 15 and 26% of those who started watching remained, and only 12% (Spanish version) or 7% (English version) of the original viewers reach the end of the video. The considerably high percentage of people clicking out early on and before the 30 second mark is reached, may be an indicator of the necessity of changing those initial seconds to be more enticing in content so it captures and engages the viewers more.
    - Simultaneously, the continuous drop in views from the beginning to the end of the video, suggests that organizing the content so that the most important and key information is in the beginning and the information that is added through time gets more specialized for those who are more interested in the matter, may be a good strategy to make sure more of the key message gets to the a majority of the audience while still satisfying the interest of those whose curiosity wants to know more.

- **The best performing videos are those that, ever since the title, have a bigger appeal to the viewers sense of wonder, curiosity, and emotions.**
    - As pointed by the creators of the white board animation YouTube channel AsapScience, and previously addressed in this report, titles are an essential aspect of the videos and have great impact in the number of views and reach

of those same videos. The authors gathered, through their experience, the idea that the tittle as to be in a way relatable to the audience: it has to be something they wonder about themselves or something that is connected to their daily lives, otherwise it is difficult to catch people's attention. Through the performance of the different individual episodes of the series it was possible to see the effects of the tittle in the overall number of viewers. Tittles which used the science behind ALMA to appeal to the viewers sense of wonder or were created to spark curiosity like "We are Stardust!" (episode III), "The Universe is a Time Machine" (episode IV) and "ALMA sees the invisible" (episode I) did significantly better, with a greater absolute number of viewers from the get go, than those who focused on more technical aspects of ALMA such as: "ALMA is state of the art technology" (episode II) or " ALMA and the cold interstellar clouds", who collected the lowest number of viewers even before the initial 3 seconds where reached. This evidence supports the observation done AsapScience creators and is a great lesson for ALMA's overall publication of videos: the right title, that is close to the audience and not over-technical, will considerably enhance the number of people reached by those same videos.

- **Further analysis would be necessary to understand the reasons behind the significant difference in performance of #WAWUA in ALMA's two Facebook pages: the videos published on the "Observatorio ALMA" were a success, having a big impact on the page, while the ones published in "ALMA Observatory" had little impact in the overall performance of the page.**
    - As pointed by Hiramatsu (2012), responsible for communicating ALMA in Japan, one of the greatest challenges faced by the communication team there, is the fact that Japan is (geographically) very distant from Chile. This is one of the reasons that may have influenced the different performances of the series in the two pages. Studies have shown that distance from (or proximity to) objects and events has implications in people's attitudes and decisions (McDonald, 2016). This so called psychological distance, that is greatly influence by geographic distance among other factors (temporal, social, etc.), has an impact in the importance (or lack there off) people give to those objects and events. This extends to ALMA and the fact that the Spanish speaking community, compose mainly by Chilean and people in

South America, having a proximity with ALMA, both geographical and social, may influence their attitude towards the institution, giving them a more open, curious and active attitude towards it (by seeing the videos and sharing them with their friends). Adding the greater number of outreach and awareness activities organized by ALMA in the country, it may explain the difference in impact the release of the videos had in the different pages.

   - Nonetheless, **the fact that animation can be easily narrated in different languages may indeed present an advantage to the possibilities it offers for outreach**, as suggested by Bello-Bravo et al. (2011). As Martinez-Conde and Macknik (2017) wrote "Cognitive science research indicates that nonnative languages evoke weaker emotions in bilingual listeners than the equivalent words in one's mother tongue." And it is probable that part of the success of the series in "Observatorio ALMA" may be due to the fact that the episodes were in Spanish, spreading and sharing the message with the users in their first language, and having the videos solely subtitle would not have the same effect.

- **A wide majority of #WAWUA's viewership happed in silence**.
   - Respectively, 55% and 78% of the overall views of the episodes in Spanish and English, happened with the sound off. This remark offers the idea that, in other to appeal and engage with the audience, the communication strategy should be more focused in making it easy for people to consume the information and messages presented in the videos without needing to turn the sound on. A relatively simple way of doing this would be to add captions to the videos. Indeed, Facebook internal tests have shown that captioned videos have an average increase of 12% in the viewed (Facebook Business, 2016).
   - Together with the two previous observations – that a major drop in the viewings happens early on and that the tittle is an extremely important component of the videos – another alteration in the format of the videos that might influence their reception and efficiency as a communication tools, would be to design them to capture the attention of the audience early on without needing sound, for example by having an initial on screen text with the title, or an interesting question, together with a striking visual.

V.2. THROUGH THE VIDEO PRODUCTION PROCESS AT ALMA

"Tell me and I forget, teach me and I may remember, involve me and I learn."

— Benjamin Franklin

Undoubtedly, a great deal of the lessons learnt during and as a result of my internship at ALMA were accomplished by surpassing the obstacles and overcoming the challenges that rose along the way. Even though extensively different in nature and origin, these obstacles and challenges are mainly related with (1) the technical challenges originated by the production of the animation videos themselves, that were mainly due to the fact that animation and design skills were not ones I possessed before starting this project; (2) the challenges faced during the production of the videos on ALMA, which however, mirror some of the most common obstacles faced by institutions, especially the ones that result of the collaborative effort of different nations, when trying to communicate themselves and the science they produce.

1. **Lessons learnt by facing the technical challenges of producing #WAWAU -** one of the most important things one can gain from an internship is newfound knowledge and skills. Despite the complete lack of knowledge I had on the production process of animation videos, both the steps involved and the software necessary to bring the videos to life. ALMA EPO team believed it would be an interesting project for me and were willing that to provide me with all the necessary resources to develop the project and give me the time to master the necessary skills via trial and error, online tutorials and lesson from the team's integral designer. It was a long and time-consuming progression, nonetheless, and in what concerns the technical skills required for producing 2D animations, I have learnt, among others:
    - To create storyboards, including their necessary written and visual components;
    - To use and make the best of two different Adobe Creative cloud software: Adobe Illustrator and After Effects. The first a software dedicated to graphic design and vector illustration, the second a software largely use for animation and video post-production;

- To setup all the necessary equipment to proceed with the recording of a voice over and to use the audio software necessary to edit that narration, such as Audacity or Adobe Audition;
- The steps involved in sound editing, including the research for sound effects and music, their integration in the overall video and the management of the sound levels.

2. **Lessons learnt by facing the non-technical challenges of producing #WAWAU -** the creation of #WAWUA was a project that involved scientists, graphic designers, communication professionals and myself. That active collaboration between professionals of not only different backgrounds, but also different origin institutions, provided a rich learning experience that went beyond technical aspects:
    - There is often a discrepancy between what it is believed by ALMA's Education and Public Outreach Office (EPO) and the communication offices of the partners institutions (ESO/NAOJ/NRAO) to be of interest to the public and target audiences, and what ALMA scientists and staff members believe is important and essential to be communicated. Finding a balance between both involves an active effort and a constant feedback loop but is possible and the result are initiatives (and videos in this case) that are simple, engaging and directed towards their audience, as well as scientifically accurate and content wise, something the scientific community is satisfied about.
    - A critical part of the process of creating the script is their external review to be done by both astronomers – who verify the accuracy of information translated from technical to more accessible language – and nonscientist stakeholders – who verify whether the concepts are clear and engaging. It is necessary to find a balance between both, which can be challenging. On one hand, astronomers often perceive the simplification of certain concepts as inaccuracies and deem the use of some jargon essential, on the other hand, not simplifying those same concepts or making use of the jargon, makes the information confusing for the lay audience. Being able to integrate the information of both kinds of reviewers was one of the most challenging yet rewarding part of the entire process.

3. **Lessons learnt by spending nine months in ALMA** - In the nine months I spent as part of ALMA's Education and Public Outreach Office I have largely fulfilled my initial objectives and surpassed all the learning goals I initially held. I have:
    - Learned through hands on experience about different approaches and nuances of institutional science communication;
    - Had direct contact with the reality and obstacles of communicating an institution compromised of a large international partnership;
    - Acquire and develop new knowledge in the field of Astronomy and Space Sciences and learn about the potential and challenges this area of science faces when it comes to communicating with the public;
    - Not only developed the technical skills in audio and visual production, but also got a better understandment of the impact video and more specifically animation video, can have in the landscape of science outreach and communication.

In ALMA I was received with open arms, given space to have a voice, and encouraged to learn by making mistakes if necessary. And all these are lessons, together with all the above mentioned, I hope to always carry with me.

CONCLUSION

Animation video offers many opportunities to communicate science in modern society. It lends itself greatly to communicate the complex scientific content behind astronomy, radio astronomy and more specifically ALMA by representing ideas and notions that are un-filmable, abstract or both, by making use of storytelling and visual stimuli to appeal to the viewers emotions and foment their curiosity and by being a very versatile channel, that can be used in different platforms, many different contexts and a variety of languages all over the world.

Additionally, with the birth of Web 2.0, animation has taken a new role in science outreach. As social media grows in importance as a channel to give the public access to scientific information and an ever-growing quantity of information is communicated through video, animation video has become a more approachable, engaging and entertaining way of creating a dialogue and promoting the interaction between science and the public.

And even though there are lessons to be learnt and possible changes and improvements than can and should be tested and applied to enhance the quality of what was produced, #WAWUA: "Why do Astronomers Want to Use ALMA?" and the five animation videos that compromise it, proved themselves to be an effective and positive alternative to face some of the challenges ALMA's Education and Public Outreach Office tackles when communicating radio astronomy and the observatory itself.

"Animation offers a medium of storytelling and visual entertainment which can bring pleasure and information to people of all ages everywhere in the world." - Walt Disney

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GLOSSARY

Traditional animation	Refers to the animation technique where animators draw by hand images, frame by frame.
Motion Graphics	Refers to the animation technique that creates the illusion of motion or rotation, and are usually combined with audio for use in multimedia projects
2D Vector-based animation	Refers to the animation technique that uses computer generated 2D drawings for animation. It uses the same techniques as traditional animation (frame-by-frame drawing) but benefits from the lack of physical objects to make traditional 2D animation.
Frame	Refers to a combination of the image to be displayed and the time the image is to be displayed. A sequence of frames makes an animation. Each frame is displayed on the screen until the next frame overwrites it.

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Figure 11. Two different scene screenshots in episode I showing the transition to illustrate the transition between two different compositions compromised of a background and in motion graphical elements.

Figure 12. Age structure of the followers of ALMA's Facebook pages. First, on the left, the Spanish version – "Observatorio ALMA". Second, on the right, the English version – "ALMA Observatory".

Figure 13. Screenshot from episode III: *"Somos Puelvo de Estrellas!".*

Figure 14. Variation in the number of viewers throughout time marks (3, 10, 30 and 120 seconds(end)) in episode I on "Observatorio ALMA" and relative number of those viewers lost from one time mark to the next.

Figure 15. Variation of the number of viewers throughout time marks (3, 10, 30 and 120 seconds(end)) in episode II on "Observatorio ALMA" and relative number of those viewers lost from one time mark to the next.

Figure 16. Variation of the number of viewers throughout time marks (3, 10, 30 and 120 seconds(end)) in episode III on "Observatorio ALMA" and relative number of those viewers lost from one time mark to the next.

Figure 17. Variation of the number of viewers throughout time marks (3, 10, 30 and 120 seconds(end)) in episode IV on "Observatorio ALMA" and relative number of those viewers lost from one time mark to the next.

Figure 18. Variation of the number of viewers throughout time marks (3, 10, 30 and 120 seconds(end)) in episode V on "Observatorio ALMA" and relative number of those viewers lost from one time mark to the next.

Figure 19. Percentage of overall views of #WAWUA episodes on "Observatorio ALMA" that were done with the sound On and with the sound Off.

Figure 20. Percentage of at least 10-second views of #WAWUA episodes on "Observatorio ALMA" that were done with the sound On and with the sound Off.

Figure 21. Variation in the lifetime number of followers in "Observatorio ALMA" Facebook page. Data collected on March 8th, 2018.

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ATTACHMENT 1. SCRIPTS

1.1. Episode I

1.1.1. English Version

What if you could only see one color? Not that everything in the world would be the same color. But you could only see things that were, for example, green. And everything else would be invisible. Not such a pleasant reality, is it? Turns out that somehow… it's true!

When you look around you, your eyes see what scientist call "visible light". And that light, the one we are used to think about, is just a very, very small portion of all the different kinds of light that exist in the Universe. And most of them are invisible to our eyes!

But there are animals that are not that blind to those kinds of light. That's why snakes can see even during moonless nights. And bees can see the flowers with the biggest amounts of pollen. They can see lights we, humans, can't! Snakes can see infrared light, the same that allows you to see if you put night-vision goggles on; and bees can see ultraviolet, the light that gets your skin burnt unless you protect yourself with sun screen.

All these lights are part of the electromagnetic spectrum, where there are also radio waves, microwaves, x-rays, and gamma rays, all the other lights we can't see, but are essential to our daily life. Microwaves are used to heat up your food and x-rays, that can go through skin, are used by doctors to see your bones.

The thing is: the story of the Universe… of galaxies, stars and planets, is told through all these different lights! And because our eyes are no good to see beyond the visible light, astronomers created new eyes that allowed them to see way more: telescopes that can see the invisible lights! ALMA is one of those telescopes. It can see radio waves.

Some places in the Universe look dark to our eyes but shine bright in radio waves. The places where stars are born, for example, are full of dust which blocks visible light and, therefore, they are very dark, but Radio telescopes like ALMA can see straight through that dust. They can see stars being born! They allow the study of things impossible to study otherwise: like galaxies that are very, very far away, or even the birth of other star systems like ours.

1.1.2. Spanish Version

Imagínate que pudieras ver un solo color. No que todo fuera del mismo color, sino que pudieras ver, por ejemplo, solo aquello de color verde. Y todo lo demás fuera invisible. No suena muy agradable, ¿cierto? Pero resulta que... ¡así es la realidad!

Tus ojos solo ven aquello que los científicos llaman “luz visible”. Y esta luz es una porción muy pequeña de todos los tipos de luz que existen en el Universo. ¡Y la mayoría de estos son invisibles a nuestros ojos!

Pero hay animales que sí pueden ver estos otros tipos de luz. Por eso las serpientes son capaces de ver en las noches más oscuras. Y las abejas distinguen las flores que tienen más polen. ¡Ambas pueden ver tipos de luz que los humanos no vemos! Las serpientes ven luz infrarroja, así como vemos con binoculares de visión nocturna, mientras que las abejas ven la luz ultravioleta, esa que puede llegar a quemarte la piel si no usas bloqueador solar.

Estos tipos de luz son parte del espectro electromagnético, como las ondas de radio, microondas, rayos x y rayos gamma, todos invisibles a nuestros ojos, pero vitales para nuestra vida. Con las microondas podemos calentar nuestra comida y con los rayos x, los cuales atraviesan la piel, los doctores pueden ver los huesos.

La historia del Universo... de las galaxias, estrellas y planetas ¡se cuenta a través de todos estos tipos de luz! ¡Y como nuestros ojos solo ven la luz visible, los astrónomos crearon nuevos ojos para poder ver también las luces invisibles! El telescopio ALMA es uno de ellos, y es capaz de observar las ondas de radio.

Ciertas zonas del Universo nos parecen oscuras, pero emiten un intenso brillo en ondas de radio. ¡Por ejemplo, donde nacen las estrellas, hay mucho polvo que impide el paso de la luz visible, y es tan obscuro que solo los radiotelescopios como ALMA pueden ver a través de ese polvo, y observar el nacimiento de las estrellas! Así estudiamos objetos imposibles de observar por otros medios, como las galaxias muy lejanas, o incluso el nacimiento de sistemas solares como el nuestro.

1.2. Episode II

1.2.1. English Version

We can't touch the stars, fly through distant galaxies or even land on planets outside our Solar System. So, the only way we can study most of the Universe and everything in it, is through light. The light we can see and the light we can't, the invisible light.

That's why telescopes are so important for astronomers: they are machines for collecting light – all kinds of it. They are very powerful artificial eyes to look at the sky.

The bigger the telescope, the better it can see. Why? Because bigger eyes – like owl's eyes – have more surface, so more light reaches them, allowing the distinction of fainter differences in color and a sharper vision. Smaller eyes – like spider eyes – have less chance of capturing light, so they have more problems in seeing details, and everything is a little blurry.

With telescopes, it's the same. If light was rain, and telescopes buckets to collect it, it's easy to think that the bigger the bucket the more rain it would be able to gather. Building very big telescopes, though, is not only expensive but also difficult and, sometimes, even impossible.

So, what if instead of trying to build a gigantic bucket, you joined a lot of smaller ones together? Well, great idea! That way you would be collecting the same amount of rain, getting the same information, but in a much easier way. Even better: what if, instead of trying to collect all the rain, you just collected some of it, with buckets spread in key places, so that you have enough to guess the characteristics of the rain falling? Well, that would be much faster and cheaper! That was precisely what astronomers though a few years ago: by using several different small telescopes as one, they could see extremely fine details of the Universe, just like if they were using a single telescope several kilometers across! They called this technique 'interferometry'.

ALMA works exactly this way, it can make 64 antennas work together as one very, very big telescope. Making it one of the sharpest eyes to ever scan the sky. So sharp, that it could detect an ant in New York if it was in Lisbon, all the way across the Atlantic Ocean! With the sharpest eyes of all, ALMA can study very faint light in the Universe and capture images astronomers can't even begin to imagine.

1.2.2. Spanish Version

Como no podemos alcanzar las estrellas, viajar a galaxias distantes ni aterrizar en planetas fuera de nuestro sistema solar, nuestra única forma de estudiar gran parte del Universo es usar la luz. Tanto la luz que podemos ver como la luz invisible para nosotros.

Por eso los telescopios son tan importantes para los astrónomos: son máquinas que recolectan luz. Son ojos artificiales muy poderosos que exploran el cielo.

Mientras más grande sea el telescopio, mejor es su visión. ¿Por qué? Porque los ojos más grandes, como los de los búhos, tienen una mayor superficie, y por lo tanto reciben más luz, por lo que distinguen más matices de colores y tienen una visión más aguda. Los ojos más pequeños, como los de las arañas, capturan menos luz, con lo cual ven menos detalles y tienen una visión más borrosa.

Con los telescopios sucede lo mismo. Si se piensa en la luz como lluvia y en los telescopios como baldes, lógicamente los baldes más grandes recogen más agua de la lluvia. Sin embargo, construir grandes telescopios no solo es caro, sino difícil, y a veces hasta imposible.

Entonces, ¿qué pasa si en vez de construir un balde gigante juntamos muchos baldes pequeños? ¡Es una excelente idea! De esa forma se puede recolectar la misma cantidad de lluvia y obtener la misma información de manera mucho más fácil. Mejor aún: ¿qué pasa si, en vez de tratar de acumular toda la lluvia, recolectamos solo una parte usando baldes dispuestos en lugares clave? ¡Así obtendríamos información suficiente para deducir las características de la lluvia de una forma más rápida y barata!

Eso es precisamente lo que los astrónomos pensaron algunas décadas atrás: al usar varios radio telescopios como si fueran uno, pueden ver detalles extremadamente pequeños del Universo, ¡como si usaran un único telescopio de varios kilómetros de diámetro! A esta técnica se le llama *interferometría*.

ALMA funciona exactamente así, uniendo hasta 64 antenas como un telescopio gigante. Es uno de los ojos más poderosos que se hayan apuntado al cielo. Tan poderoso, que podría detectar una hormiga en Nueva York desde Lisboa, ¡atravesando todo el océano Atlántico! Con una visión tan aguda, ALMA puede estudiar luz muy tenue en el Universo y capturar imágenes que los astrónomos ni siquiera se imaginan.

1.3. Episode III

1.3.1. English Version

What are you made of? You're made of matter, which is made of molecules, which are made of atoms. But where did those atoms come from? The ones in you! How were they formed? Well, they were created inside of stars! Really, you're made of star stuff!

Life needs a lot of different kinds of atoms to exist, like hydrogen, carbon, and oxygen, but when the Universe began there was only hydrogen and helium: the very, very simplest atoms of all, and nothing else. Where did the others come from, then? Well, there's only one thing capable of creating bigger, more complex atoms: Stars!

Stars are born when clouds of dust and gas become very, very small due to the force of gravity. So small that the atoms in them don't have enough room anymore, getting extremely squeezed together and everything starts heat up. The temperature gets so incredible high, that the smaller and simpler atoms are transformed into bigger and more complex ones – in a chain reaction called nuclear fusion.

The iron in your blood, the calcium in your bones and the carbon in your muscles were created in stars across the Universe. Stars that died and left dust and gas full of the new elements to eventually form other stars, planets, and life. Our Sun is, at least, a second-generation star. Which means that all the atoms in our Solar System were created in an older star.

But how and where did those atoms form the molecules that ultimately became you and every living thing that ever existed? Well, no one knows yet, but ALMA might be a great help to find it out.

Large molecules, the ones that could be the building blocks of life, can only exist in dark and cold places in the Universe, places very difficult to study through visible light. But ALMA can see the faint radio light emitted by the coldest things in Space. And it can peer through those dark clouds where stars and planets are born and, maybe, discover where and when the first building blocks of life are created – answering one of the greatest questions of mankind.

Studying theses atoms and molecules is, in a way, like studying yourself. So, next time you think astronomy is the study of things that are far away and unrelated to you, remember, we are all made of stardust!

1.3.2. Spanish Version

¿De qué estamos hechos? Estamos hechos de materia, hecha a su vez de moléculas, que están hechas de átomos. ¿Pero de dónde provienen todos los átomos que están en nuestro cuerpo? Es simple: ¡se crearon dentro de estrellas! ¡En serio! ¡Estamos hechos de polvo de estrellas!

La vida necesita muchos tipos de átomos para existir, como el hidrógeno, el carbono y el oxígeno. Pero cuando el Universo recién se formó había solo hidrógeno y helio, los dos átomos más simples de todos, y nada más. ¿Y entonces, de dónde salieron los otros átomos? Del único lugar capaz de crear átomos más grandes y complejos: ¡las estrellas!

Las estrellas nacen cuando en las nubes de gas y polvo los átomos se concentran en zonas muy, pero muy pequeñas por efecto de la gravedad, apretándose al punto que empiezan a calentarse. La temperatura sube tanto que los átomos más pequeños y simples se vuelven más grandes y complejos, en una reacción en cadena llamada *fusión nuclear*.

El hierro presente en nuestra sangre, el calcio de nuestros huesos y el carbono de nuestros músculos se formaron en estrellas en todo el Universo. En estrellas que se extinguieron y dejaron restos de polvo y gas llenos de elementos nuevos que luego darían nacimiento a otras estrellas y planetas y crearían vida. Nuestro Sol, por ejemplo, es una estrella de al menos segunda generación. Es decir, todos los átomos de nuestro sistema solar se formaron en una estrella más antigua.

¿Pero cómo y dónde esos átomos forjaron las moléculas que terminaron generando nuestro cuerpo y todos los seres vivos que han existido? Nadie lo sabe, pero ALMA podría ayudar a descubrirlo.

Las moléculas grandes, las que pueden generar vida, sólo sobreviven en los rincones fríos y oscuros del Universo, lugares muy difíciles de estudiar a través de la luz visible. Pero ALMA es capaz de captar la débil luz de radio emitida por los objetos más fríos del espacio. De esa forma, ALMA puede ver a través de las oscuras nubes donde nacen las estrellas y los planetas y, quizás, descubrir dónde y cuándo se crearon los primeros componentes de la vida.

Estudiar estos átomos y moléculas de cierta forma equivale a estudiarnos a nosotros mismos. Así que cuando pensemos que la astronomía es una ciencia que estudia objetos lejanos y ajenos a nosotros, ¡no olvidemos que estamos hechos de polvo de estrellas!

1.4. Episode IV

1.4.1. English Version

How can astrophysicists study the story of the Universe? Billions of years ago, when the Big Bang happened, there was no Milky Way Galaxy, no Solar System, no planet Earth and, especially, no human beings to witness these and all the events that followed. So, how would they know about this stuff?

Well, it turns out that the Universe is, somehow, like a time machine. When looking at things in the sky, we are looking at their past. Yeah, it's a bit confusing but try it this way: When you hear a plane, you probably have a hard time spotting it in the sky. You look in the direction where the sound came from, but the plane is no longer there. That's because its sound took some time to reach you, and by the time it did, the plane had already moved on. In a way, you were "hearing back in time", as the sound you perceived was the one that left the plane seconds before.

With light it's exactly the same. Even though light is much faster than sound – in fact, it is the fastest thing we know - it still needs time to get from where it is emitted to where it is seen. The farther the object, the longer it takes for light to make the journey to the observer.

By looking at galaxies that are very far away from us, whose light takes billions and billions of years to reach us, we are seeing them how they looked like billions of years ago: when the Universe was much younger, and they were just beginning to form.

But, as we look at galaxies that are closer and closer to us, studying them throughout time, it's possible to see how they age and change. Just like if we were looking at babies, children, teenagers, and adults to see how humans develop.

The problem is when things are very far away from you, it gets to a point where it's impossible for your eyes to distinguish details. Telescopes, especially the ones that see the same kind of light as we do, also have a limit and are not able the detect the light emitted by the first galaxies ever formed, as they are too distant, and their light is too faint.

In those galaxies, however, the first stars were born. And even though there's no telescope powerful enough to see them shine, there's a telescope powerful enough to detect the dust from which they formed. ALMA, with its incredible sharpness and ability to see radio light, can distinguish the dust and gas clouds which formed the first generations of stars in the Universe. This can help astronomers know a little bit more about these early phases of time and space which are fundamental to understand our present.

1.4.2. Spanish Version

¿Cómo hacen los astrofísicos para estudiar la historia del Universo? Hace miles de millones de años, cuando se produjo el Big Bang, no había Vía Láctea ni sistema solar ni Tierra y por lo tanto no había seres humanos que fueran testigos de estos y otros acontecimientos posteriores. Entonces ¿cómo hacen para saber todo esto?

Sucede que el Universo es un poco como una máquina del tiempo. Cuando miramos el cielo, vemos los astros como eran en el pasado. Suena un poco extraño, pero veámoslo de otra forma: al escuchar un avión es probable que nos cueste encontrarlo en el cielo. Miramos en dirección del sonido, pero el avión ya no está. Esto se debe a que el sonido tarda en llegar a nuestros oídos, y cuando llega, el avión ya avanzó. De cierta forma, estábamos "escuchando el pasado", puesto que el sonido que oímos era el que había sido generado por el avión algunos segundos antes.

Con la luz pasa exactamente lo mismo. Aunque ésta es mucho más rápida que el sonido –de hecho, no hay nada más rápido que la luz–, necesita tiempo para desplazarse desde el punto de origen hasta el lugar donde es percibida. Mientras más lejos se encuentre un objeto, más tiempo tarda su luz en llegar hasta el observador.

Cuando observamos las galaxias que están muy lejos de nosotros, y cuya luz tarda miles de millones de años en alcanzarnos, las vemos tal como eran hace miles de millones de años, es decir, cuando el Universo era mucho más joven y estos astros recién comenzaban a formarse.

Y cuando observamos las galaxias más cercanas y vemos su evolución en el tiempo, podemos ver cómo envejecen y cambian. Es como si estudiáramos a los bebés, los niños, los adolescentes y los adultos para ver cómo se desarrollan los seres humanos.

El problema se da cuando los objetos están tan lejos que se vuelve imposible distinguir detalles. Los telescopios, sobre todo los que observan el mismo tipo de luz que vemos nosotros, también tienen un alcance limitado, y no pueden detectar la luz emitida por las primeras galaxias que se formaron, debido a que están muy lejos y son muy tenues.

Pero en esas galaxias nacieron las primeras estrellas. Y aunque ningún telescopio es lo suficientemente potente como para captar su brillo. ALMA, con su increíble precisión y su capacidad para observar emisiones de radio, puede distinguir las nubes de polvo y gas donde nacieron las primeras generaciones de estrellas en el Universo. Esto ayudará a los astrónomos a entender un poco mejor los comienzos del tiempo y el espacio, tan importantes para entender nuestro presente.

1.5. Episode V

1.5.1. English Version

Your home and the Universe have at least one thing in common: they can be very dusty places! When you get back after a very long vacation, it may happen that the windows in your home are so full of dust that you can't see through them anymore. Surprisingly, astronomers have a similar problem! When using optical telescopes – telescopes that can see the same light we do - they are not able to see through the dustiest places in the Universe, as they appear like dark walls blocking the view.

And just as you may miss lots of interesting things happening outside because of the dusty glass, some of the most important events in the Universe occur within vast clouds of cold dust and gas. Stars and planets, for example, are born within those clouds, which are dark to most telescopes.

Astronomers want to understand how these births happen as both stars and their planets are essential for life: you need a planet to live on and a star to provide the energy that allows you to survive. So, there are two options: either find a way to clean the dust or get some special goggles that see through it. For you, the first option would be easier, but astronomers have no choice: they can't clean the dust out of space; they need to build something special that can see through dust.

With the help of engineers, they created radio telescopes, and ALMA is one of them. These are telescopes that see a kind of light – called radio light – that is not blocked by dust. Moreover, some things in the Universe are so cold, that they don't produce enough energy to be seen in visible light. However, they happen to emit radio light, because these kind of light is produced by less energetic processes.

Therefore, even though you can see our Sun and other stars through their childhood, teenage years, and adulthood, only radio telescopes are able to see stars that are just being born and aren't producing enough energy yet. Only radio telescopes, as well, can look at the planets forming in the dusty disks around those new born stars.

So why are there some stars that get to be so much larger than others? How do planets form around new born stars? Why are some star systems are so different from our own? Well, these are questions ALMA will help unravel.

1.5.2. Spanish Version

Nuestros hogares y el Universo tienen algo en común: ¡pueden llenarse de polvo! Cuando regresamos de vacaciones muy prolongadas nuestras ventanas pueden estar tan sucias que ya no podemos ver a través de ellas. Los astrónomos tienen un problema similar: cuando usan telescopios ópticos, es decir, que ven la misma luz que nosotros, no logran observar a través de los rincones más polvorientos del Universo; son como muros oscuros que tapan la vista.

Al igual que cuando dejamos de ver todo lo que pasa afuera por causa de nuestras ventanas sucias, también nos perdemos algunos de los acontecimientos más importantes del Universo que ocurren dentro de grandes nubes de gas y polvo. Las estrellas y los planetas, por ejemplo, nacen dentro de esas nubes, demasiado oscuras para la mayoría de los telescopios.

Los astrónomos quieren entender cómo ocurren estos nacimientos, puesto que las estrellas y los planetas son elementos imprescindibles para la vida: se necesita un planeta donde vivir y una estrella que proporcione energía. Para eso, hay dos opciones: encontrar una forma de barrer el polvo o usar unos binoculares especiales para atravesarlo. Para nosotros, la primera opción sería fácil, pero no para los astrónomos: como no pueden limpiar el espacio, necesitan construir una herramienta especial que vea más allá del polvo.

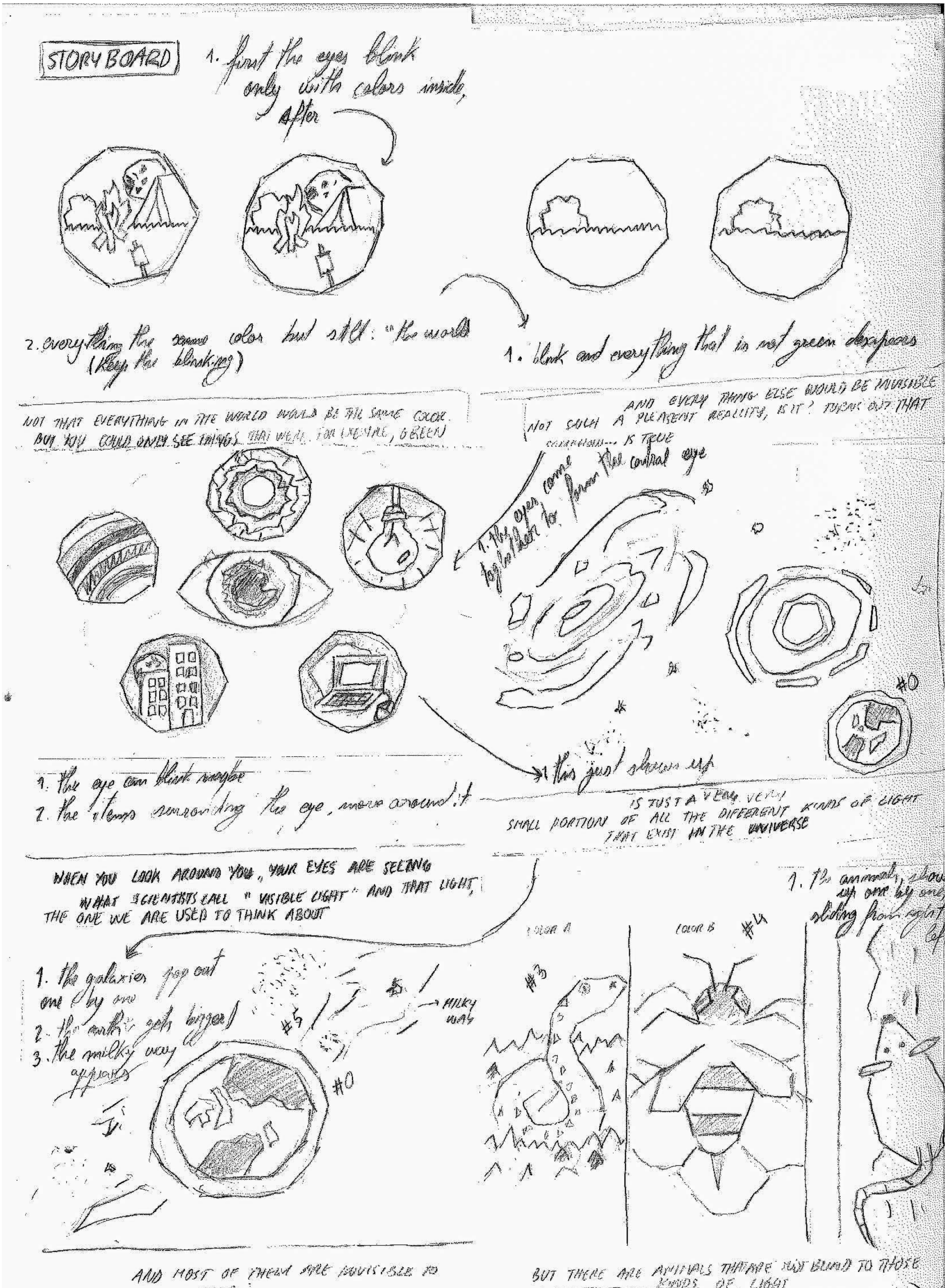
Con la ayuda de ingenieros, se desarrollaron radiotelescopios. Uno de ellos es ALMA. Estos telescopios ven un tipo de luz que no es tapado por el polvo: las emisiones de radio. Algunos objetos del Universo son tan fríos que no producen energía suficiente para ser vistos en la luz visible, pero emiten ondas de radio, generadas por procesos menos energéticos.

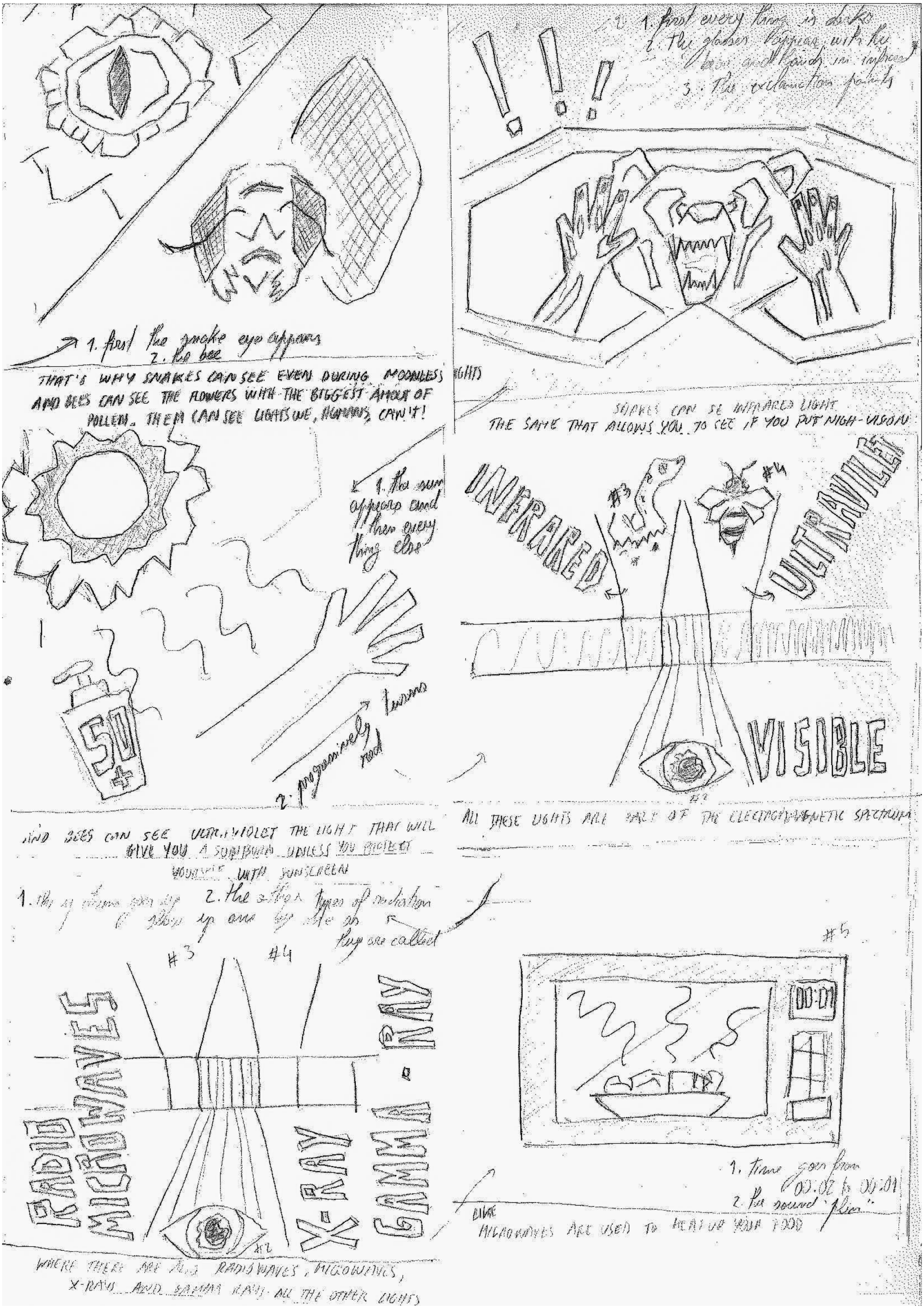
Por lo tanto, aunque podamos ver el Sol y otras estrellas durante su infancia, su adolescencia y su adultez, solo los radiotelescopios pueden ver las estrellas en pleno nacimiento, ya que generan poca energía, y además observar los planetas en proceso de formación en los discos de polvo que rodean las estrellas recién nacidas.

Y nosotros nos preguntamos: ¿por qué algunas estrellas son mucho más grandes que otras? ¿Cómo se forman los planetas alrededor de estrellas recién nacidas? ¿Por qué algunos sistemas solares son tan diferentes del nuestro? Estas son algunas de las preguntas que ALMA ayudará a responder.

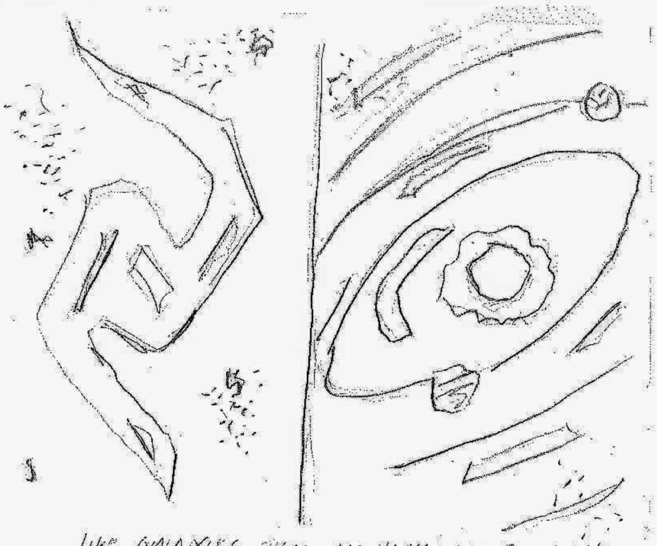
ATTACHMENT 2. STORYBOARDS

2.1. Episode I




1. first the snake eye appears
2. the bee
THAT'S WHY SNAKES CAN SEE EVEN DURING MOONLESS NIGHTS
AND BEES CAN SEE THE FLOWERS WITH THE BIGGEST AMOUNT OF POLLEN. THEM CAN SEE LIGHTS WE, HUMANS, CAN'T!
1. first every thing is dark
3. The exclamation points
THE SAME THAT ALLOWS YOU TO SEE IF YOU PUT NIGH-VISON
1. the sun appears and then every thing else
2. progressively turns red
50
UNFRARED
ULTRAVILET
VISIBLE
#3
#4
AND BEES CAN SEE ULTRAVIOLET THE LIGHT THAT WILL GIVE YOU A SUNBURN UNLESS YOU PROTECT YOURSELF WITH SUNSCREEN
ALL THESE LIGHTS ARE PART OF THE ELECTROMAGNETIC SPECTRUM
2. the other types of radiation
they are called
#5
00:01
RADIO
MICROWAVES
X-RAY
GAMMA-RAY
#2
1. Time goes from 00:02 to 00:01
2. the sound
MICROWAVES ARE USED TO HEAT UP YOUR FOOD
WHERE THERE ARE ALSO RADIOWAVES, MICROWAVES,
X-RAYS AND GAMMA RAYS ALL THE OTHER LIGHTS

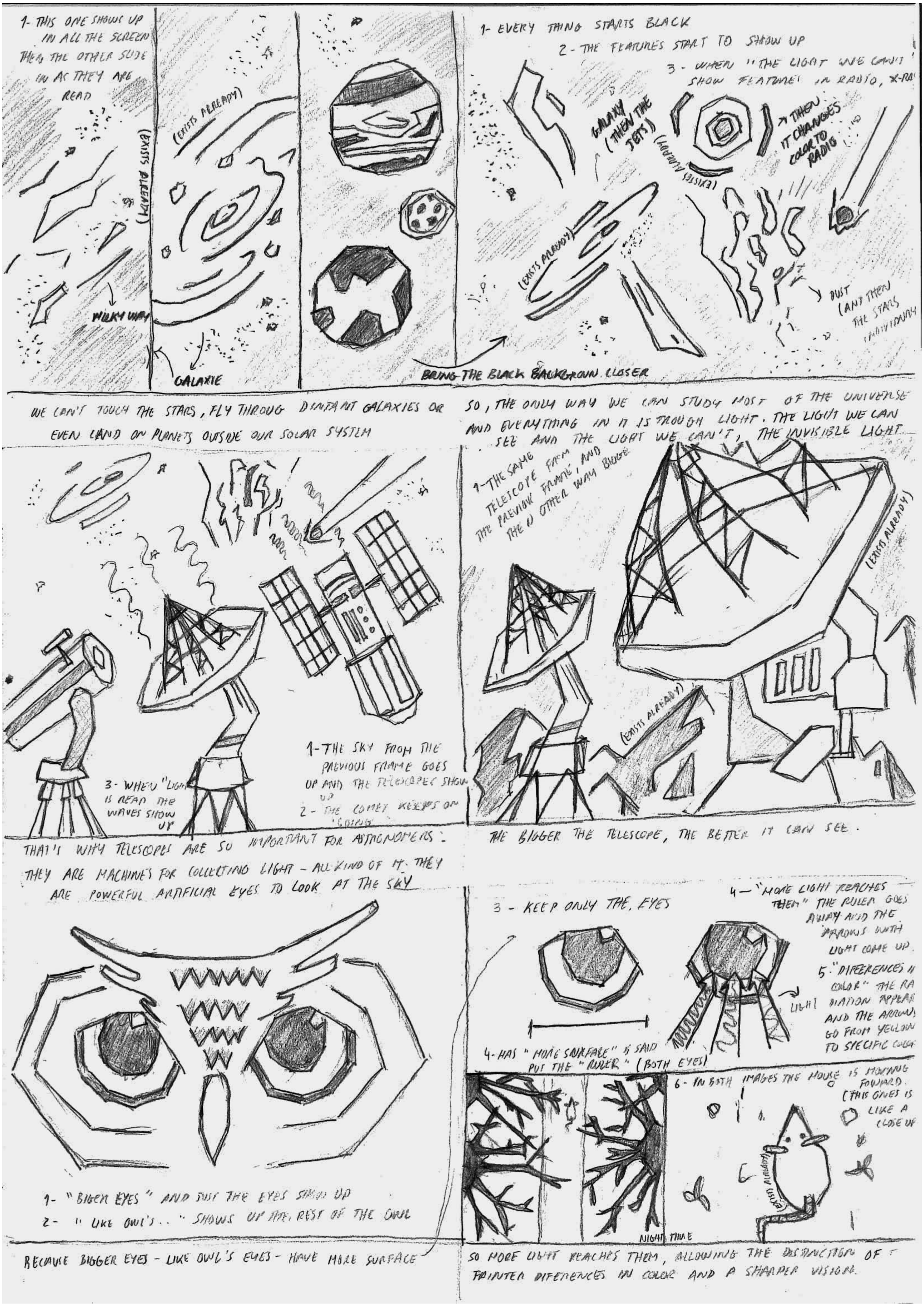

2. the X-ray appears
#5
AND X-RAYS, THAT CAN GO TROUGH SKIN, ARE USED BY DOCTORS TO SEE YOUR BONES
1. new colors come up on top of the existing structures (radio colors)
1. add a little bit of movement
THE THING IS: THE STORY OF THE UNIVERSE
THE VISIBLE LIGHT
#5
MILKY WAY
2. a new structure comes up
ASTRONOMERS CREATED NEW EYES THAT ALLOWED THEM TO SEE WAY MORE: TELESCOPES THAT CAN SEE INVISIBLE LIGHT
ALMA IS ONE OF THOSE TELESCOPES. IT CAN SEE
star being born
SOME PLACES IN THE UNIVERSE LOOK DARK TO OUR EYES BUT
THE PLACES WHERE STARS ARE BORN, FOR EXAMPLE, FULL OF DUST AND, THEREFORE VERY DARK
BUT RADIO TELESCOPES LIKE ALMA CAN SEE STRAIGHT THROUGH THAT DUST. THEY CAN SEE STARS BEING BORN.
AND ALLOW THE STORY OF THINGS THAT WOULD BE IMPOSSI

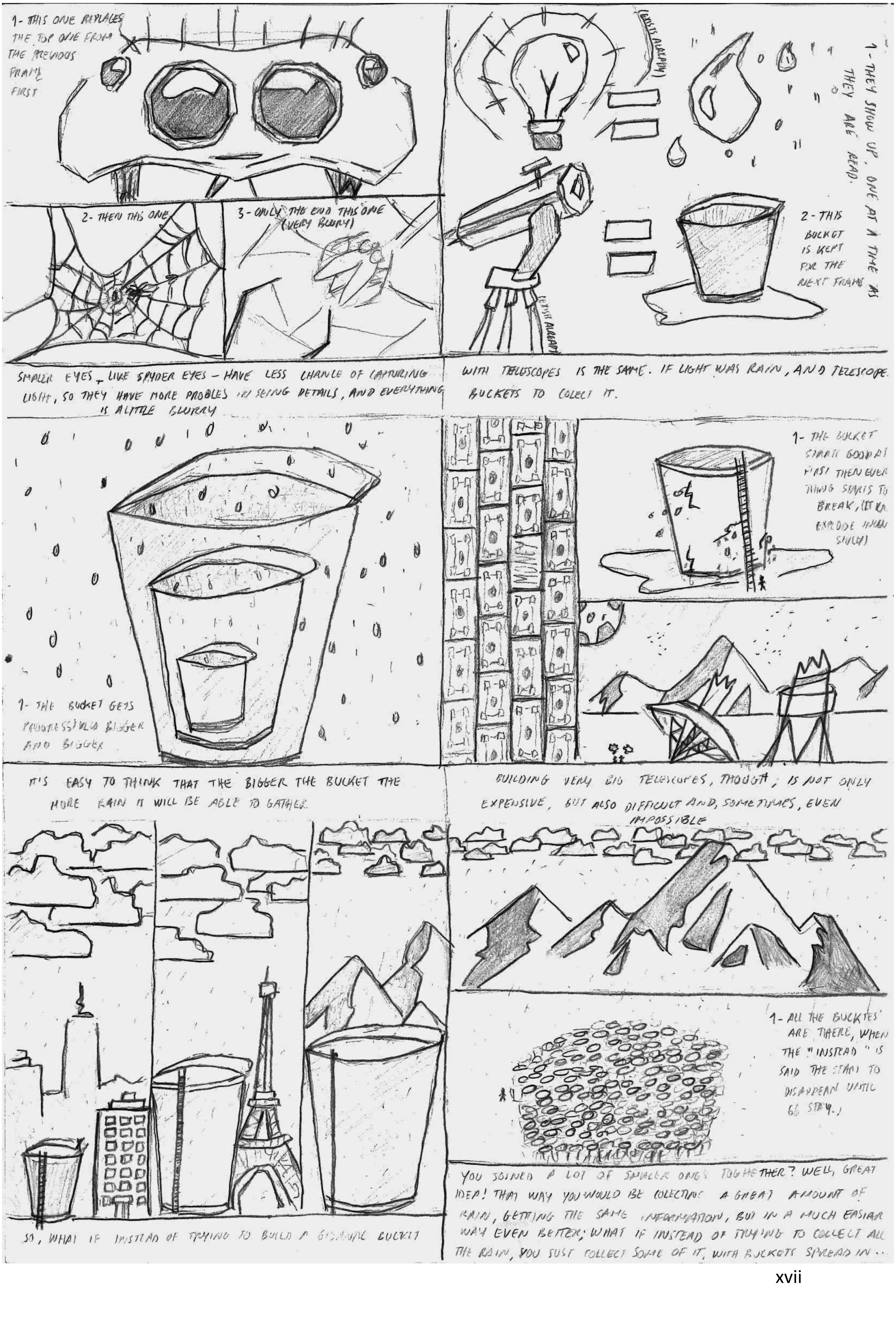


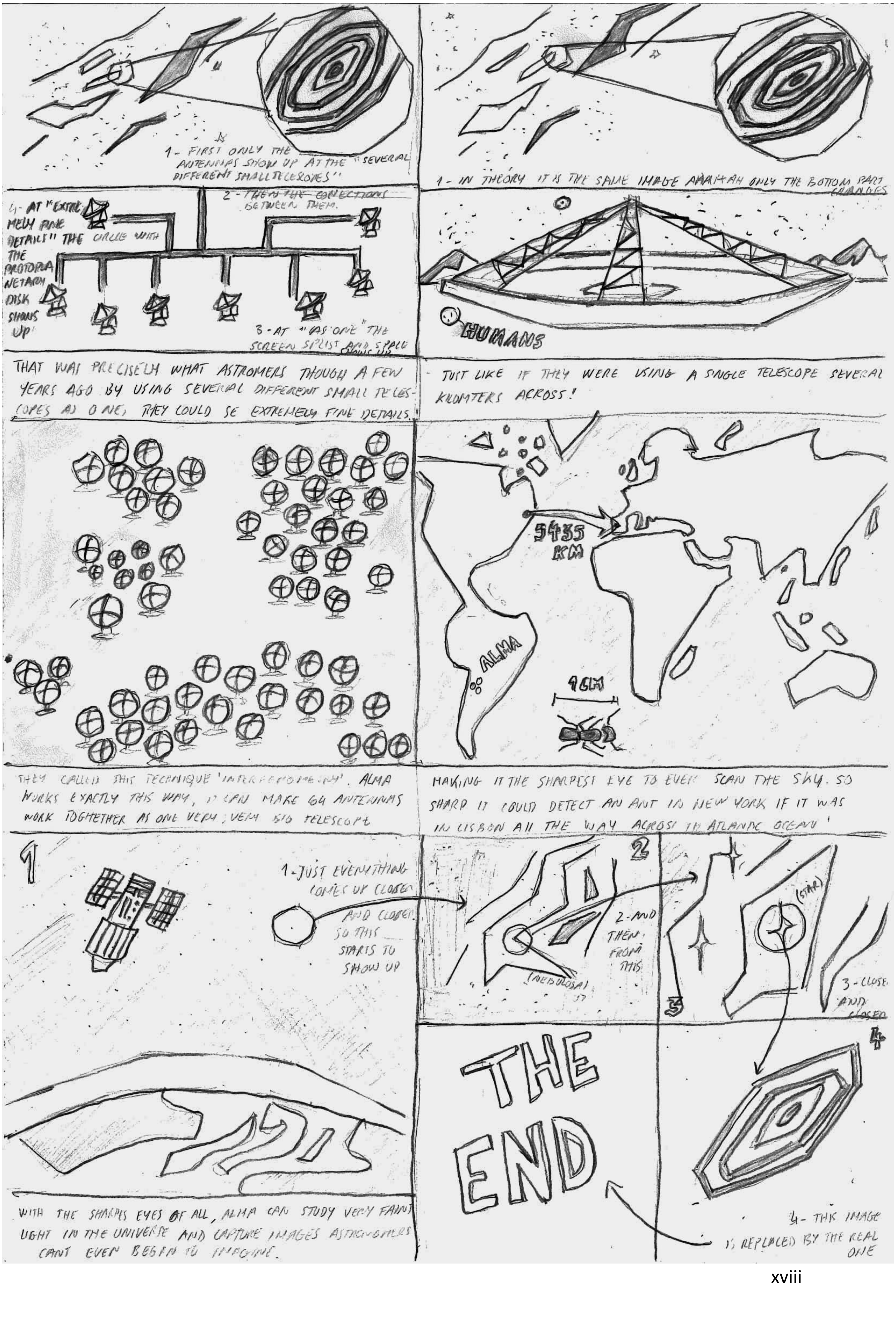
LIKE GALAXIES THAT ARE VERY VERY FAR AWAY, OR EVEN THE BIRTH OF OTHER STAR SYSTEMS LIKE OURS

THE END

2.2. Episode II

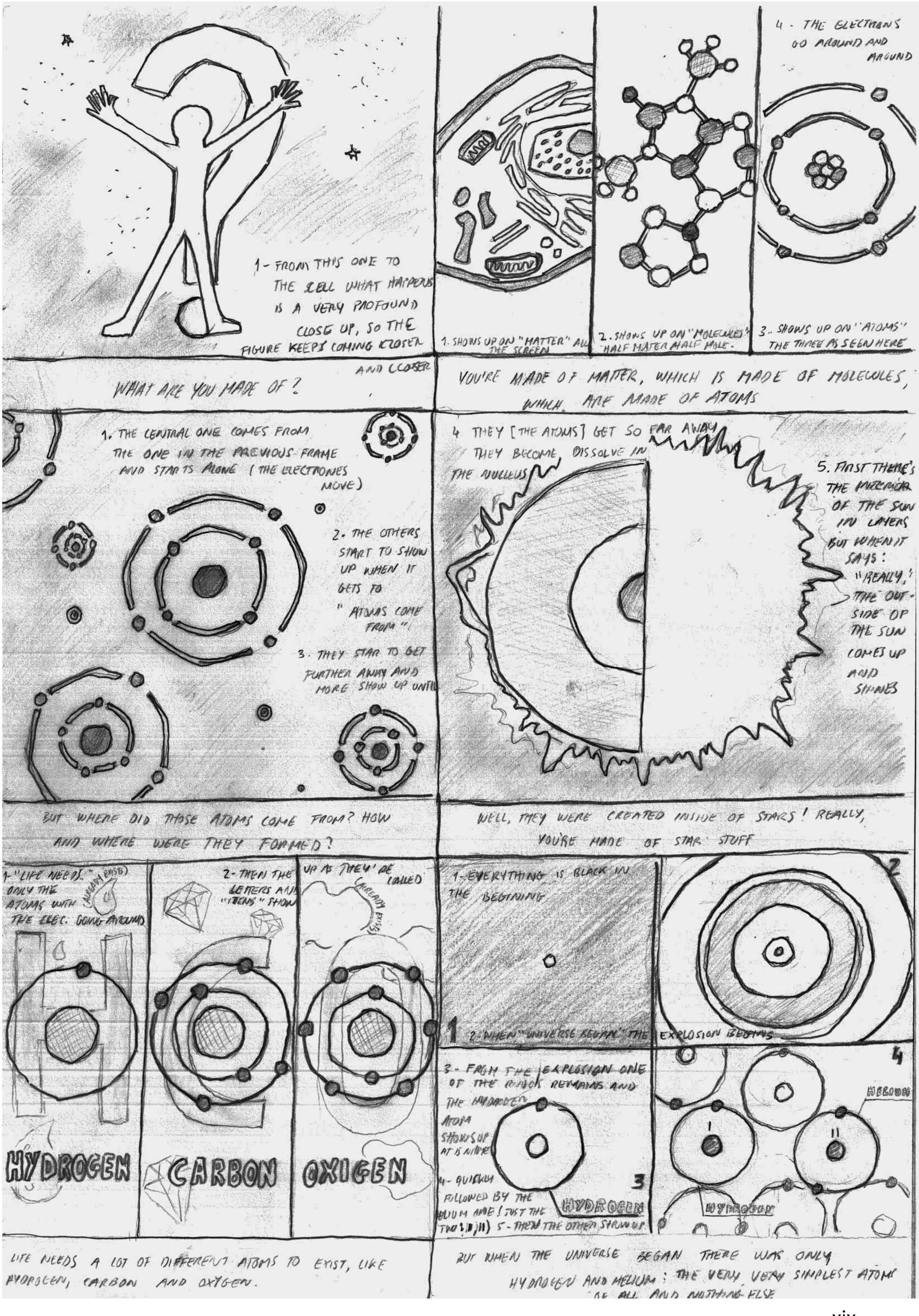


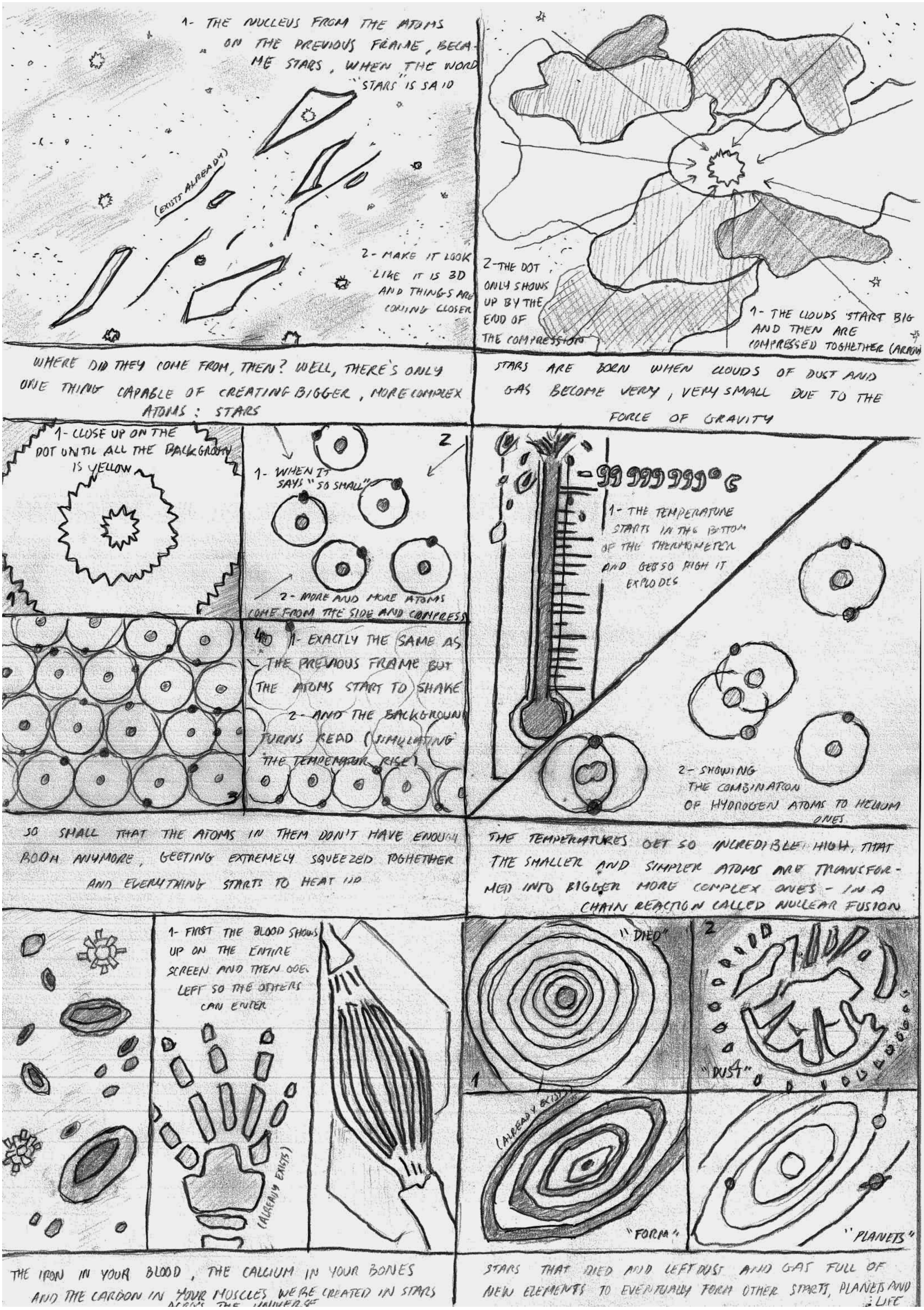

1- THIS ONE REPLACES THE TOP ONE FROM THE PREVIOUS FRAME FIRST
2- THEN THIS ONE
3- ONLY THE END THIS ONE (VERY BLURRY)
1- THEY SHOW UP, ONE AT A TIME AS THEY ARE READ.
2- THIS BUCKET IS KEPT FOR THE NEXT FRAME
SMALLER EYES, LIKE SPYDER EYES - HAVE LESS CHANCE OF CAPTURING LIGHT, SO THEY HAVE MORE PROBLES IN SEING DETAILS, AND EVERYTHING IS A LITTLE BLURRY
WITH TELESCOPES IS THE SAME. IF LIGHT WAS RAIN, AND TELESCOPE BUCKETS TO COLECT IT.
1- THE BUCKET GETS PROGRESSIVLY BIGGER AND BIGGER
MONEY
1- THE BUCKET STARTS GOOD AT FIRST THEN EVERYTHING STARTS TO BREAK,
IT'S EASY TO THINK THAT THE BIGGER THE BUCKET THE MORE RAIN IT WILL BE ABLE TO GATHER
BUILDING VERY BIG TELESCOPES, THOUGH, IS NOT ONLY EXPENSIVE, BUT ALSO DIFFICULT AND, SOMETIMES, EVEN IMPOSSIBLE
1- ALL THE BUCKTES ARE THERE, WHEN THE "INSTEAD" IS SAID THE START TO DISAPPEAR UNTIL 66 STAY.)
SO, WHAT IF INSTEAD OF TRYING TO BUILD A GIGANTIC BUCKET
YOU JOINED A LOT OF SMALLER ONES TOGHETHER? WELL, GREAT IDEA! THAT WAY YOU WOULD BE COLLECTING A GREAT AMOUNT OF RAIN, GETTING THE SAME INFORMATION, BUT IN A MUCH EASIER WAY. EVEN BETTER, WHAT IF INSTEAD OF TRYING TO COLLECT ALL THE RAIN, YOU JUST COLLECT SOME OF IT, WITH BUCKETS SPREAD IN...

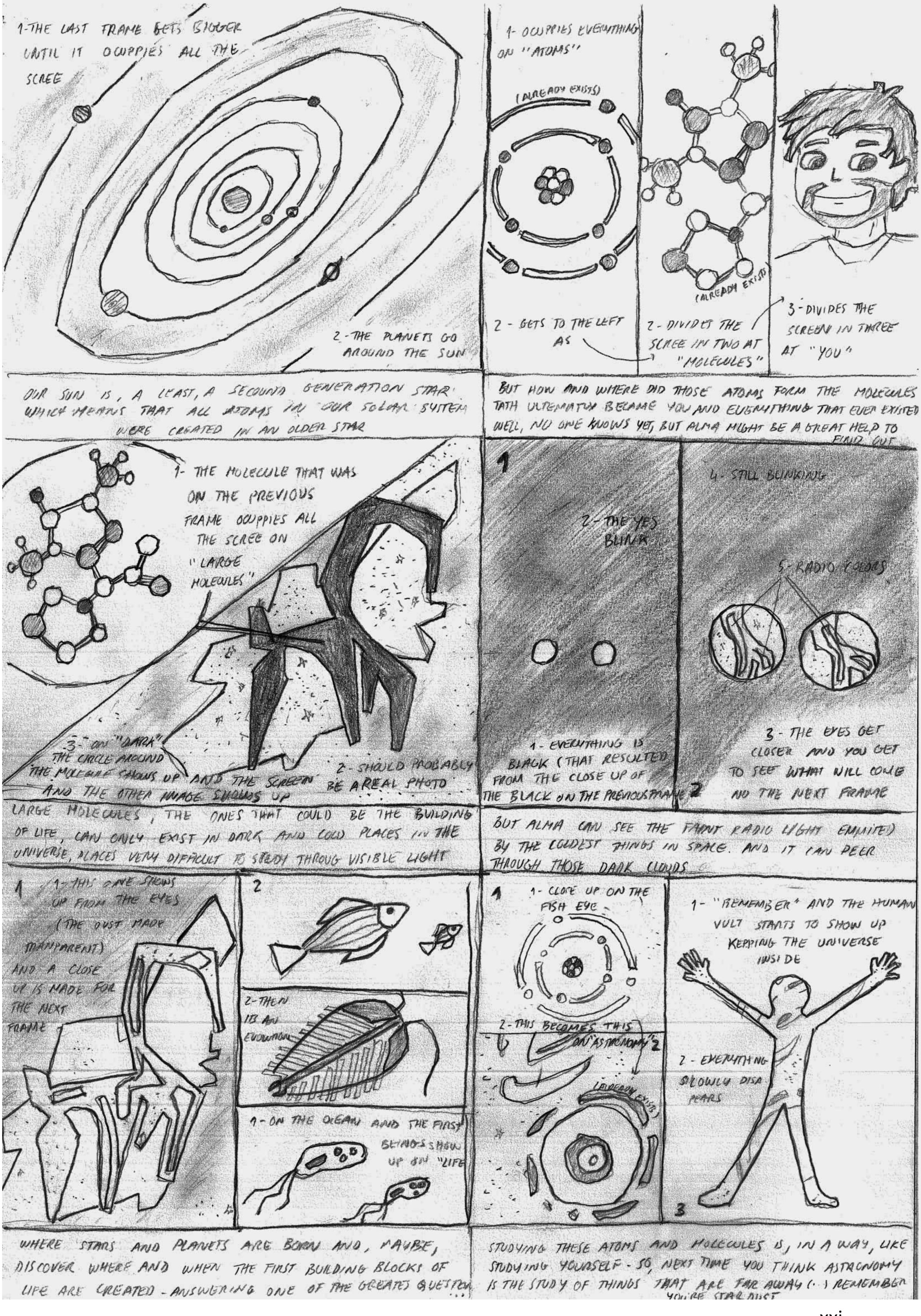


1 - FIRST ONLY THE ANTENNAS SHOW UP AT THE "SEVERAL DIFFERENT SMALL TELESCOPES"
1 - IN THEORY IT IS THE SAME IMAGE ONLY THE BOTTOM PART CHANGES
4 - AT "EXTREMELY FINE DETAILS" THE CIRCLE WITH THE PROTOPLANETARY DISK SHOWS UP
2 - THEN THE CONECTIONS BETWEEN THEM.
3 - AT "AS ONE" THE SCREEN SPLIST AND SPACE SHOWS UP
HUMANS
THAT WAS PRECISELY WHAT ASTROMERS THOUGH A FEW YEARS AGO BY USING SEVERAL DIFFERENT SMALL TELESCOPES AS ONE, THEY COULD SE EXTREMELY FINE DETAILS.
- JUST LIKE IF THEY WERE USING A SINGLE TELESCOPE SEVERAL KILOMTERS ACROSS!
5435 KM
ALMA
1CM
THEY CALLED THIS TECHNIQUE 'INTERFEROMETRY'. ALMA WORKS EXACTLY THIS WAY, IT CAN MAKE 64 ANTENNAS WORK TOGHETHER AS ONE VERY, VERY BIG TELESCOPE
MAKING IT THE SHARPEST EYE TO EVER SCAN THE SKY. SO SHARP IT COULD DETECT AN ANT IN NEW YORK IF IT WAS IN LISBON ALL THE WAY ACROSS THE ATLANTIC OCEAN!
1
1 - JUST EVERYTHING COMES UP CLOSER AND CLOSER SO THIS STARTS TO SHOW UP
2
2 - AND THEN FROM THIS
(NEBULOSA)
(STAR)
3
3 - CLOSER AND CLOSER
4
THE END
WITH THE SHARPES EYES OF ALL, ALMA CAN STUDY VERY FAINT LIGHT IN THE UNIVERSE AND CAPTURE IMAGES ASTRONOMERS CANT EVEN BEGIN TO IMAGINE.
4 - THIS IMAGE IS REPLACED BY THE REAL ONE

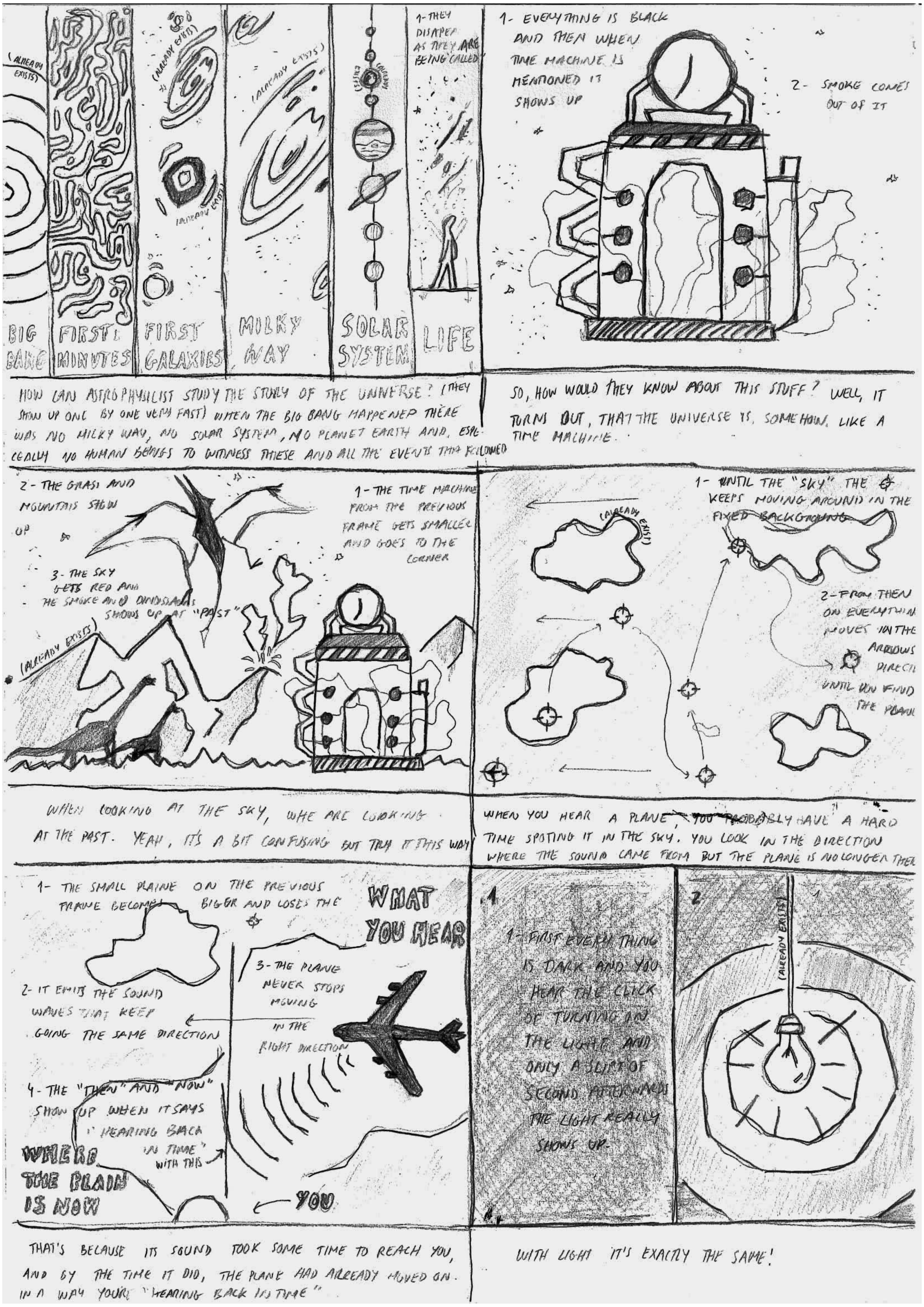
2.3. Episode III

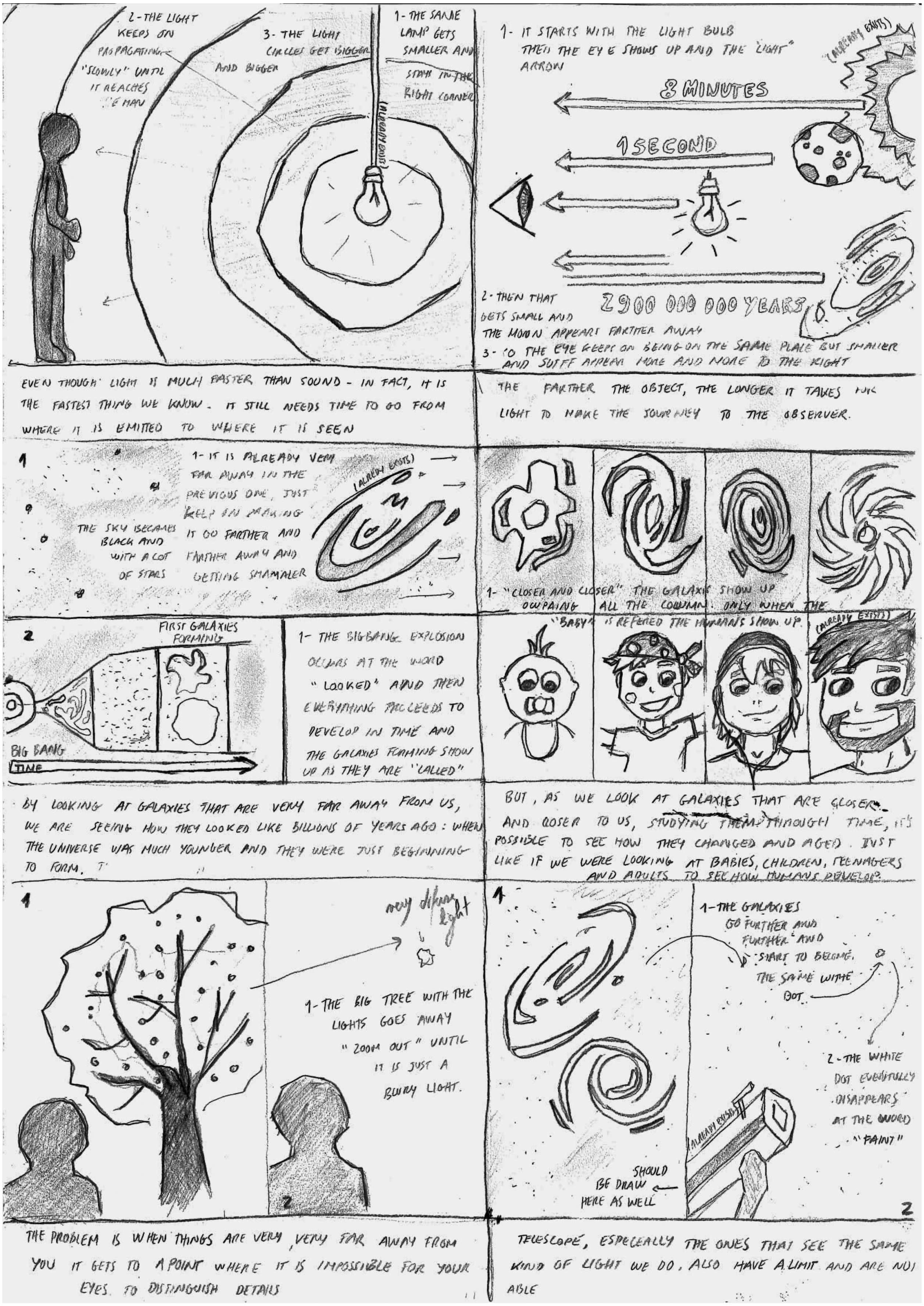


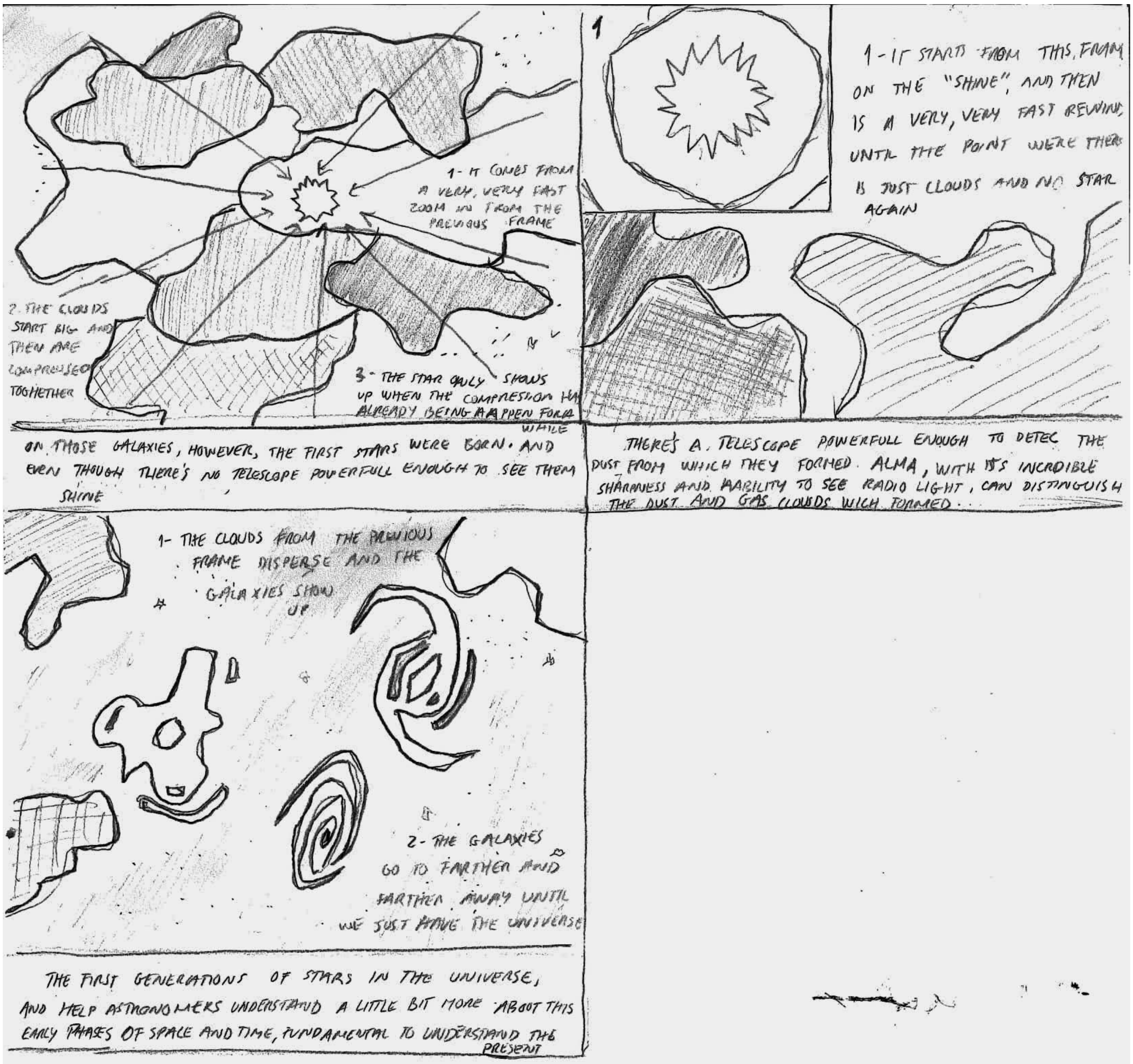

1- THE NUCLEUS FROM THE ATOMS ON THE PREVIOUS FRAME, BECAME STARS, WHEN THE WORD "STARS" IS SAID
(EXISTS ALREADY)
2- MAKE IT LOOK LIKE IT IS 3D AND THINGS ARE COMING CLOSER
2- THE DOT ONLY SHOWS UP BY THE END OF THE COMPRESSION
1- THE CLOUDS START BIG AND THEN ARE COMPRESSED TOGHETHER
WHERE DID THEY COME FROM, THEN? WELL, THERE'S ONLY ONE THING CAPABLE OF CREATING BIGGER, MORE COMPLEX ATOMS : STARS
STARS ARE BORN WHEN CLOUDS OF DUST AND GAS BECOME VERY, VERY SMALL DUE TO THE FORCE OF GRAVITY
1- CLOSE UP ON THE DOT UNTIL ALL THE BACKGROUND IS YELLOW
1- WHEN IT SAYS "SO SMALL"
2
2- MORE AND MORE ATOMS COME FROM THE SIDE AND COMPRESS
-99 999 999° C
1- THE TEMPERATURE STARTS IN THE BOTTOM OF THE THERMOMETER AND GETS SO HIGH IT EXPLODES
1- EXACTLY THE SAME AS THE PREVIOUS FRAME BUT THE ATOMS START TO SHAKE
2- AND THE BACKGROUND TURNS READ (SIMULATING THE TEMPERATURE RISE)
2- SHOWING THE COMBINATION OF HYDROGEN ATOMS TO HELIUM ONES
SO SMALL THAT THE ATOMS IN THEM DON'T HAVE ENOUGH ROOM ANYMORE, GEETING EXTREMELY SQUEEZED TOGHETHER AND EVERYTHING STARTS TO HEAT UP
THE TEMPERATURES GET SO INCREDIBLE HIGH, THAT THE SMALLER AND SIMPLER ATOMS ARE TRANSFORMED INTO BIGGER MORE COMPLEX ONES - IN A CHAIN REACTION CALLED NUCLEAR FUSION
1- FIRST THE BLOOD SHOWS UP ON THE ENTIRE SCREEN AND THEN GOES LEFT SO THE OTHERS CAN ENTER
(ALREADY EXISTS)
"DIED"
2
"DUST"
1
(ALREADY EXISTS)
"FORM"
"PLANETS"
THE IRON IN YOUR BLOOD, THE CALCIUM IN YOUR BONES AND THE CARBON IN YOUR MUSCLES WERE CREATED IN STARS ACROSS THE UNIVERSE
STARS THAT DIED AND LEFT DUST AND GAS FULL OF NEW ELEMENTS TO EVENTUALLY FORM OTHER STARS, PLANETS AND LIFE


1-THE LAST FRAME GETS BIGGER UNTIL IT OCUPPIES ALL THE SCREE
2-THE PLANETS GO AROUND THE SUN
1- OCUPPIES EVERYTHING ON "ATOMS"
(ALREADY EXISTS)
2 - GETS TO THE LEFT AS
2 - DIVIDES THE SCREE IN TWO AT "MOLECULES"
(ALREADY EXISTS)
3 - DIVIDES THE SCREEN IN THREE AT "YOU"
OUR SUN IS, A LEAST, A SECOUND GENERATION STAR WHICH MEANS THAT ALL ATOMS IN OUR SOLAR SYSTEM WERE CREATED IN AN OLDER STAR
BUT HOW AND WHERE DID THOSE ATOMS FORM THE MOLECULES TATH ULTEMATLY BECAME YOU AND EVERYTHING THAT EVER EXISTED WELL, NO ONE KNOWS YET, BUT ALMA MIGHT BE A GREAT HELP TO FIND OUT
1- THE MOLECULE THAT WAS ON THE PREVIOUS FRAME OCUPPIES ALL THE SCREE ON "LARGE MOLECULES"
3- ON "DARK" THE CIRCLE AROUND THE MOLECULE SHOWS UP AND THE SCREEN AND THE OTHER IMAGE SHOWS UP
2- SHOULD PROBABLY BE A REAL PHOTO
1
2- THE YES BLINK
1 - EVERYTHING IS BLACK (THAT RESULTED FROM THE CLOSE UP OF THE BLACK ON THE PREVIOUS FRAME
2
4- STILL BLINKING
5- RADIO COLORS
3 - THE EYES GET CLOSER AND YOU GET TO SEE WHAT WILL COME NO THE NEXT FRAME
LARGE MOLECULES, THE ONES THAT COULD BE THE BUILDING OF LIFE, CAN ONLY EXIST IN DARK AND COLD PLACES IN THE UNIVERSE, PLACES VERY DIFFICULT TO STUDY THROUG VISIBLE LIGHT
BUT ALMA CAN SEE THE FAINT RADIO LIGHT EMMITED BY THE COLDEST THINGS IN SPACE. AND IT CAN PEER THROUGH THOSE DARK CLOUDS
1
1- THIS ONE SHOWS UP FROM THE EYES (THE DUST MADE TRANSPARENT) AND A CLOSE UP IS MADE FOR THE NEXT FRAME
2
2- THEN IS AN EVOLUTION
1- ON THE OCEAN AND THE FIRST BEINGS SHOW UP ON "LIFE
1
1- CLOSE UP ON THE FISH EYE
2- THIS BECOMES THIS ON "ASTRONOMY" 2
(ALREADY EXISTS)
1- "REMEMBER" AND THE HUMAN VULT STARTS TO SHOW UP KEEPING THE UNIVERSE INSIDE
2 - EVERYTHING SLOWLY DISAPEARS
3
WHERE STARS AND PLANETS ARE BORN AND, MAYBE, DISCOVER WHERE AND WHEN THE FIRST BUILDING BLOCKS OF LIFE ARE CREATED - ANSWERING ONE OF THE GREATES QUESTION
STUDYING THESE ATOMS AND MOLECULES IS, IN A WAY, LIKE STUDYING YOURSELF - SO, NEXT TIME YOU THINK ASTRONOMY IS THE STUDY OF THINGS THAT ARE FAR AWAY (...) REMEMBER YOU'RE STAR DUST

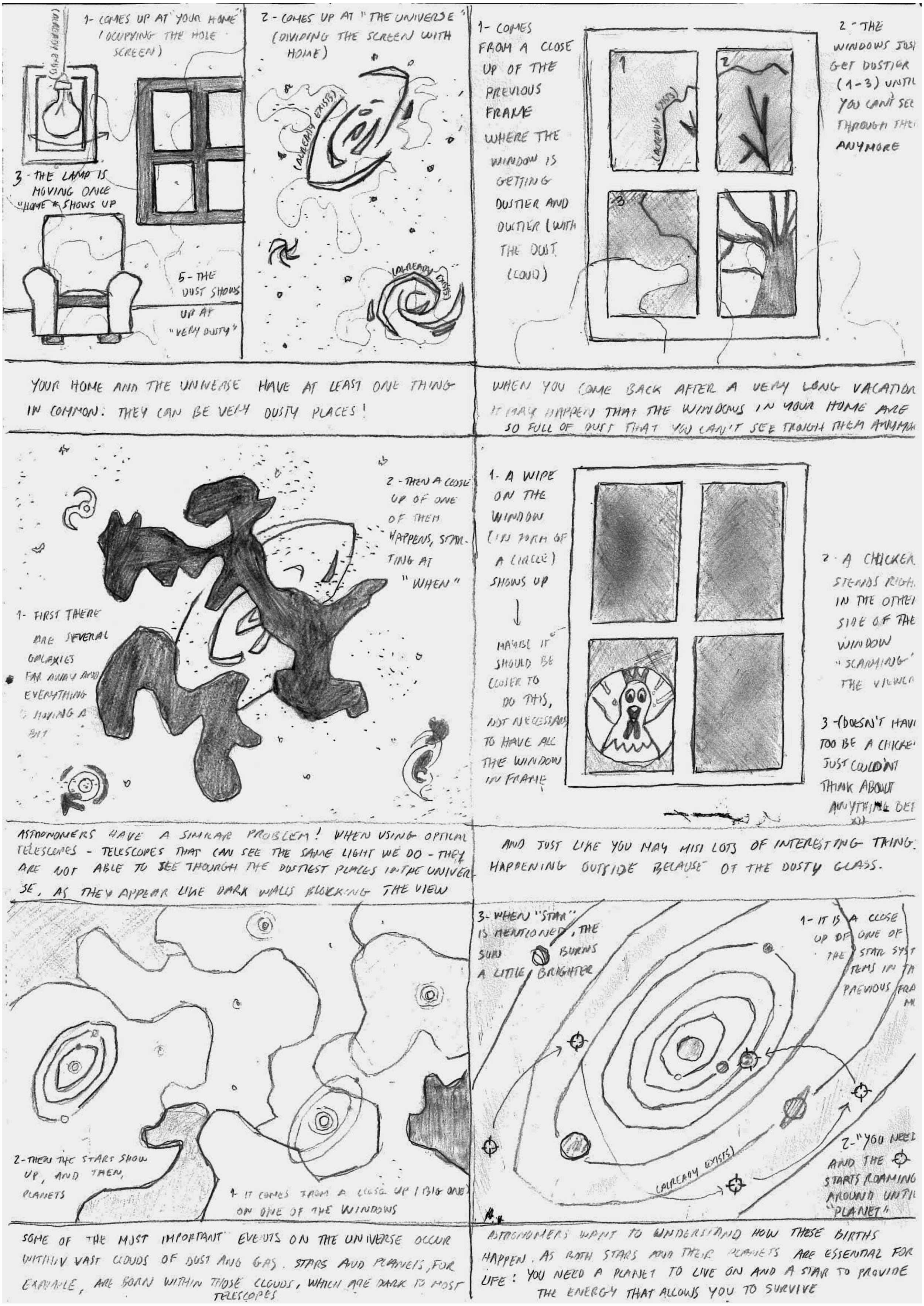
2.4. Episode IV

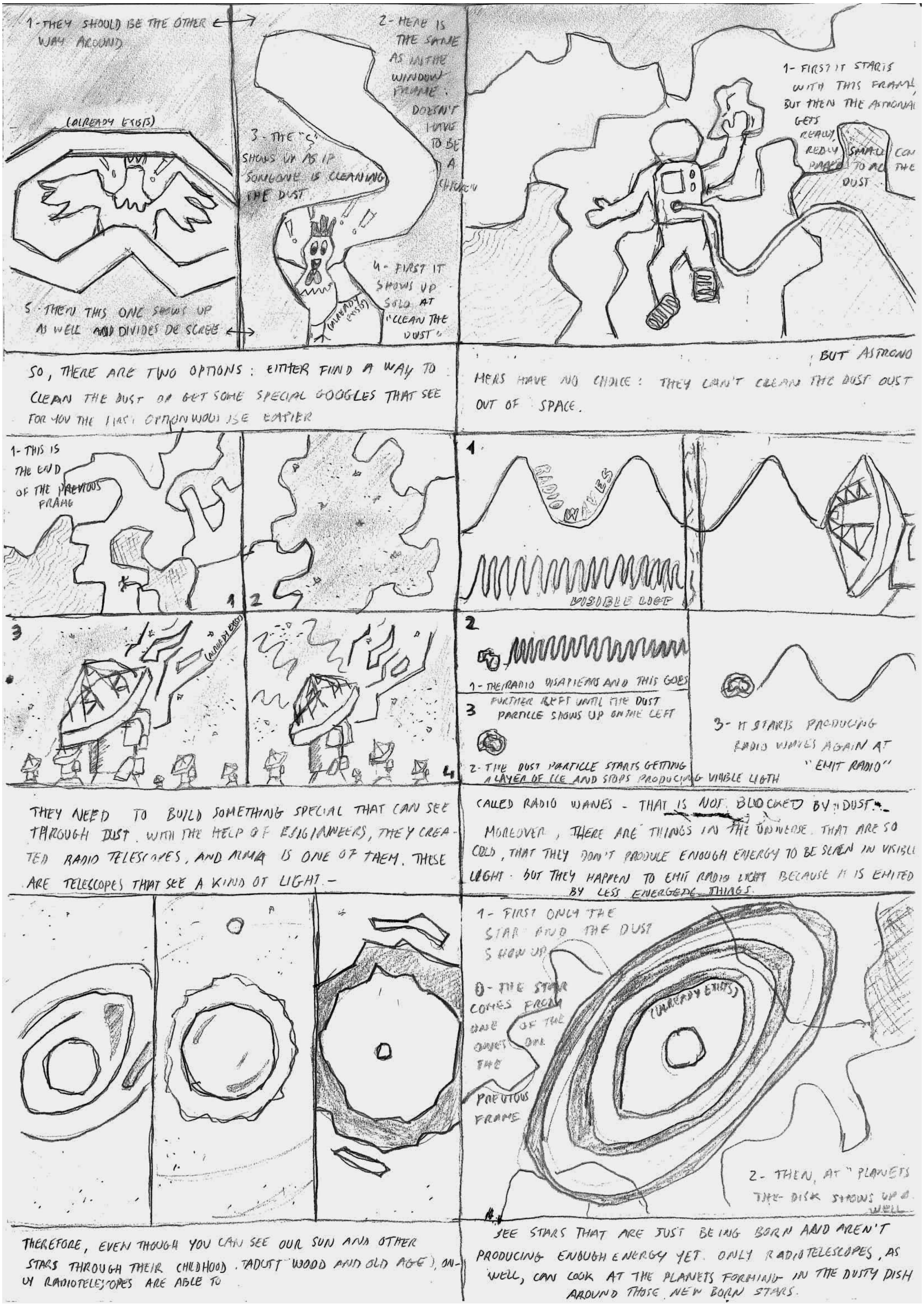


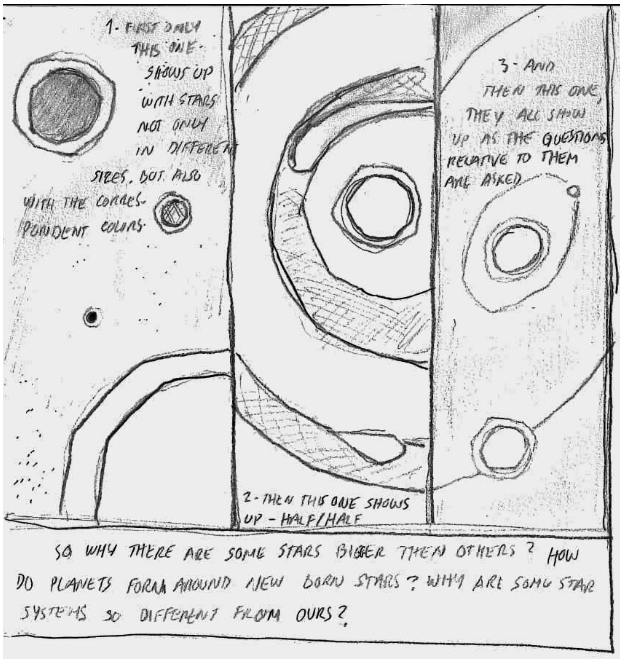

2 - THE LIGHT KEEPS ON PROPAGATING "SLOWLY" UNTIL IT REACHES THE MAN
3 - THE LIGHT CIRCLES GET BIGGER AND BIGGER
1 - THE SAME LAMP GETS SMALLER AND STAY IN THE RIGHT CORNER
(ALREADY EXISTS)
1 - IT STARTS WITH THE LIGHT BULB THEN THE EYE SHOWS UP AND THE "LIGHT" ARROW
(ALREADY EXISTS)
8 MINUTES
1 SECOND
2 900 000 000 YEARS
2 - THEN THAT GETS SMALL AND THE MOON APPEARS FARTHER AWAY
3 - SO THE EYE KEEPS ON BEING ON THE SAME PLACE BUT SMALLER AND STUFF APPEAR MORE AND MORE TO THE RIGHT
EVEN THOUGH LIGHT IS MUCH FASTER THAN SOUND - IN FACT, IT IS THE FASTEST THING WE KNOW - IT STILL NEEDS TIME TO GO FROM WHERE IT IS EMITTED TO WHERE IT IS SEEN
THE FARTHER THE OBJECT, THE LONGER IT TAKES FOR LIGHT TO MAKE THE JOURNEY TO THE OBSERVER.
1
1 - IT IS ALREADY VERY FAR AWAY IN THE PREVIOUS ONE, JUST KEEP ON MAKING IT GO FARTHER AND FARTHER AWAY AND GETTING SMAMALER
THE SKY BECAMES BLACK AND WITH A LOT OF STARS
(ALREADY EXISTS)
1 - "CLOSER AND CLOSER" THE GALAXIS SHOW UP OCUPAING ALL THE COLUMN. ONLY WHEN THE "BABY" IS REFERED THE HUMANS SHOW UP.
(ALREADY EXISTS)
2
FIRST GALAXIES FORMING
BIG BANG
TIME
1 - THE BIGBANG EXPLOSION OCCURS AT THE WORD "LOOKED" AND THEN EVERYTHING PROCEEDS TO DEVELOP IN TIME AND THE GALAXIES FORMING SHOW UP AS THEY ARE "CALLED"
BY LOOKING AT GALAXIES THAT ARE VERY FAR AWAY FROM US, WE ARE SEEING HOW THEY LOOKED LIKE BILLIONS OF YEARS AGO: WHEN THE UNIVERSE WAS MUCH YOUNGER AND THEY WERE JUST BEGINNING TO FORM.
BUT, AS WE LOOK AT GALAXIES THAT ARE CLOSER AND CLOSER TO US, STUDYING THEM THROUGH TIME, IT'S POSSIBLE TO SEE HOW THEY CHANGED AND AGED. JUST LIKE IF WE WERE LOOKING AT BABIES, CHILDREN, TEENAGERS AND ADULTS TO SEE HOW HUMANS DEVELOP.
1
very difuse light
1 - THE BIG TREE WITH THE LIGHTS GOES AWAY "ZOOM OUT" UNTIL IT IS JUST A BLURY LIGHT.
2
1
1 - THE GALAXIES GO FURTHER AND FURTHER AND START TO BECOME THE SAME WHITE DOT
2 - THE WHITE DOT EVENTUALLY DISAPPEARS AT THE WORD "PAINT"
(ALREADY EXISTS)
SHOULD BE DRAW HERE AS WELL
2
THE PROBLEM IS WHEN THINGS ARE VERY, VERY FAR AWAY FROM YOU IT GETS TO A POINT WHERE IT IS IMPOSSIBLE FOR YOUR EYES TO DISTINGUISH DETAILS
TELESCOPE, ESPECIALLY THE ONES THAT SEE THE SAME KIND OF LIGHT WE DO, ALSO HAVE A LIMIT AND ARE NOT ABLE


1- IT COMES FROM A VERY, VERY FAST ZOOM IN FROM THE PREVIOUS FRAME
2. THE CLOUDS START BIG AND THEN ARE COMPRESSED TOGHETHER
3- THE STAR ONLY SHOWS UP WHEN THE COMPRESSION HA ALREADY BEING HAPPEN FOR A WHILE
ON THOSE GALAXIES, HOWEVER, THE FIRST STARS WERE BORN. AND EVEN THOUGH THERE'S NO TELESCOPE POWERFULL ENOUGH TO SEE THEM SHINE
1
1- IT STARTS FROM THIS, FROM ON THE "SHINE", AND THEN IS A VERY, VERY FAST REWIND UNTIL THE POINT WERE THERE IS JUST CLOUDS AND NO STAR AGAIN
THERE'S A TELESCOPE POWERFULL ENOUGH TO DETEC THE DUST FROM WHICH THEY FORMED. ALMA, WITH IT'S INCREDIBLE SHARPNESS AND ABILITY TO SEE RADIO LIGHT, CAN DISTINGUISH THE DUST AND GAS CLOUDS WICH FORMED...
1- THE CLOUDS FROM THE PREVIOUS FRAME DISPERSE AND THE GALAXIES SHOW UP
2- THE GALAXIES GO TO FARTHER AND FARTHER AWAY UNTIL WE JUST HAVE THE UNIVERSE
THE FIRST GENERATIONS OF STARS IN THE UNIVERSE, AND HELP ASTRONOMERS UNDERSTAND A LITTLE BIT MORE ABOUT THIS EARLY PHASES OF SPACE AND TIME, FUNDAMENTAL TO UNDERSTAND THE PRESENT

2.5. Episode V


1- COMES UP AT YOUR HOME (OCCUPYING THE HOLE SCREEN)
(ALREADY EXISTS)
3- THE LAMP IS MOVING ONCE "HOME" SHOWS UP
5- THE DUST SHOWS UP AT "VERY DUSTY"
2- COMES UP AT "THE UNIVERSE" (DIVIDING THE SCREEN WITH HOME)
(ALREADY EXISTS)
1- COMES FROM A CLOSE UP OF THE PREVIOUS FRAME WHERE THE WINDOW IS GETTING DUSTIER AND DUSTIER (WITH THE DUST (CLOUD)
2- THE WINDOWS JUST GET DUSTIER (1-3) UNTIL YOU CAN'T SEE THROUGH THEM ANYMORE
YOUR HOME AND THE UNIVERSE HAVE AT LEAST ONE THING IN COMMON: THEY CAN BE VERY DUSTY PLACES!
WHEN YOU COME BACK AFTER A VERY LONG VACATION IT MAY HAPPEN THAT THE WINDOWS IN YOUR HOME ARE SO FULL OF DUST THAT YOU CAN'T SEE TROUGH THEM ANYMORE
2- THEN A CLOSE UP OF ONE OF THEM HAPPENS, STARTING AT "WHEN"
1- FIRST THERE ARE SEVERAL GALAXIES FAR AWAY AND EVERYTHING IS MOVING A BIT
1- A WIPE ON THE WINDOW (IN FORM OF A CIRCLE) SHOWS UP
MAYBE IT SHOULD BE CLOSER TO DO THIS, NOT NECESSARY TO HAVE ALL THE WINDOW IN FRAME
2- A CHICKEN STANDS RIGHT IN THE OTHER SIDE OF THE WINDOW "SCARING" THE VIEWER
3- (DOESN'T HAVE TOO BE A CHICKEN JUST COULDN'T THINK ABOUT ANYTHING BETTER)
ASTRONOMERS HAVE A SIMILAR PROBLEM! WHEN USING OPTICAL TELESCOPES - TELESCOPES THAT CAN SEE THE SAME LIGHT WE DO - THEY ARE NOT ABLE TO SEE THROUGH THE DUSTIEST PLACES IN THE UNIVERSE, AS THEY APPEAR LIKE DARK WALLS BLOCKING THE VIEW
AND JUST LIKE YOU MAY MISS LOTS OF INTERESTING THINGS HAPPENING OUTSIDE BECAUSE OF THE DUSTY GLASS.
2- THEN THE STARS SHOW UP, AND THEN, PLANETS
1- IT COMES FROM A CLOSE UP / BIG ONE ON ONE OF THE WINDOWS
3- WHEN "STAR" IS MENTIONED, THE SUN BURNS A LITTLE BRIGHTER
1- IT IS A CLOSE UP OF ONE OF THE STAR SYSTEMS IN THE PREVIOUS FRAME
(ALREADY EXISTS)
2- "YOU NEED AND THE ⌖ STARTS ROAMING AROUND UNTIL "PLANET"
SOME OF THE MOST IMPORTANT EVENTS ON THE UNIVERSE OCCUR WITHIN VAST CLOUDS OF DUST AND GAS. STARS AND PLANETS, FOR EXAMPLE, ARE BORN WITHIN THOSE CLOUDS, WHICH ARE DARK TO MOST TELESCOPES
ASTRONOMERS WANT TO UNDERSTAND HOW THESE BIRTHS HAPPEN. AS BOTH STARS AND THEIR PLANETS ARE ESSENTIAL FOR LIFE: YOU NEED A PLANET TO LIVE ON AND A STAR TO PROVIDE THE ENERGY THAT ALLOWS YOU TO SURVIVE


1- THEY SHOULD BE THE OTHER WAY AROUND
(ALREADY EXISTS)
5- THEN THIS ONE SHOWS UP AS WELL AND DIVIDES DE SCREE
2- HERE IS THE SAME AS IN THE WINDOW FRAME. DOESN'T HAVE TO BE A CHICKEN
3- THE "S" SHOWS UP AS IF SOMEONE IS CLEANING THE DUST
4- FIRST IT SHOWS UP SOLO AT "CLEAN THE DUST"
(ALREADY EXISTS)
1- FIRST IT STARTS WITH THIS FRAME, BUT THEN THE ASTRONAUT GETS REALLY, REALLY SMALL COMPARED TO ALL THE DUST
SO, THERE ARE TWO OPTIONS: EITHER FIND A WAY TO CLEAN THE DUST OR GET SOME SPECIAL GOOGLES THAT SEE FOR YOU THE FIRST OPTION WOULD BE EASIER
BUT ASTRONOMERS HAVE NO CHOICE: THEY CAN'T CLEAN THE DUST OUST OUT OF SPACE.
1- THIS IS THE END OF THE PREVIOUS FRAME
1
2
1
RADIO WAVES
VISIBLE LIGHT
3
(ALREADY EXISTS)
4
2
1- THE RADIO DISAPEARS AND THIS GOES FURTHER LEFT UNTIL THE DUST PARTICLE SHOWS UP ON THE LEFT
3
2- THE DUST PARTICLE STARTS GETTING A LAYER OF ICE AND STOPS PRODUCING VISIBLE LIGTH
3- IT STARTS PRODUCING RADIO WAVES AGAIN AT "EMIT RADIO"
THEY NEED TO BUILD SOMETHING SPECIAL THAT CAN SEE THROUGH DUST. WITH THE HELP OF ENGINEERS, THEY CREATED RADIO TELESCOPES, AND ALMA IS ONE OF THEM. THESE ARE TELESCOPES THAT SEE A KIND OF LIGHT -
CALLED RADIO WAVES - THAT IS NOT BLOCKED BY DUST.
MOREOVER, THERE ARE THINGS IN THE UNIVERSE THAT ARE SO COLD, THAT THEY DON'T PRODUCE ENOUGH ENERGY TO BE SEEN IN VISIBLE LIGHT. BUT THEY HAPPEN TO EMIT RADIO LIGHT BECAUSE IT IS EMITED BY LESS ENERGETIC THINGS.
1- FIRST ONLY THE STAR AND THE DUST SHOW UP
0- THE STAR COMES FROM ONE OF THE ONES ON THE PREVIOUS FRAME
(ALREADY EXISTS)
2- THEN, AT "PLANETS" THE DISK SHOWS UP AS WELL
THEREFORE, EVEN THOUGH YOU CAN SEE OUR SUN AND OTHER STARS THROUGH THEIR CHILDHOOD, ADULTHOOD AND OLD AGE), ONLY RADIOTELESCOPES ARE ABLE TO
SEE STARS THAT ARE JUST BEING BORN AND AREN'T PRODUCING ENOUGH ENERGY YET. ONLY RADIOTELESCOPES, AS WELL, CAN LOOK AT THE PLANETS FORMING IN THE DUSTY DISK AROUND THOSE NEW BORN STARS.


1- FIRST ONLY THIS ONE SHOWS UP WITH STARS NOT ONLY IN DIFFERENT SIZES, BUT ALSO WITH THE CORRES-PONDENT COLORS.
2- THEN THIS ONE SHOWS UP - HALF/HALF
3- AND THEN THIS ONE, THEY ALL SHOW UP AS THE QUESTIONS RELATIVE TO THEM ARE ASKED
SO WHY THERE ARE SOME STARS BIGGER THEN OTHERS? HOW DO PLANETS FORM AROUND NEW BORN STARS? WHY ARE SOME STAR SYSTEMS SO DIFFERENT FROM OURS?

ATTACHMENT 3. *CLIPPING* OF MEDIA RELEASES

3.1. La Tercera – Daily newspaper published in Santiago, Chile**:** *“Observatorio Alma estrena su propria serie animada para explicar el universo”.* **Published:** 7th of September 2017

Observatorio Alma estrena su propia serie animada para explicar el universo

Autor: La Tercera

La primera temporada 5 episodios de dos minutos de duración cada uno que explican conceptos como interferometría, astroquímica, espectro electromagnético, Universo frío, entre otros, de manera didáctica.

El observatorio astronómico Alma lanzó una nueva serie de animaciones breves que buscan explicar **“¿Por qué los astrónomos quieren usar Alma ?”** o #WAWUA por su nombre en inglés (*Why Astronomers Want to Use Alma?*). Se trata de **5 episodios de dos minutos de duración cada uno**, que se irán liberando semanalmente los días jueves a través del sitio web y redes sociales de Alma, junto con las de sus socios en Europa, Asia del Este y Norteamérica.

La tecnología y la ciencia detrás de Alma son explicadas de manera didáctica y simple en estos videos. Con originales y coloridos dibujos se ahonda en conceptos aparentemente difíciles como **interferometría, astroquímica, espectro electromagnético, Universo frío, polvo de estrellas, moléculas complejas, y longitud de onda.**

Este nuevo proyecto de difusión del radiotelescopio se desarrolló gracias a la práctica llevada a cabo por la portuguesa María Corrêa-Mendes, Máster de Comunicación Científica de la Universidad Nova de Lisboa, quien arribó hace un año atrás al Departamento de Comunicaciones y Educación de Alma. Sus excelentes competencias creativas y habilidades para dibujar, motivó al resto del equipo a hacer **una serie de videos animados para explicar temas específicos relacionados al observatorio y a la radioastronomía.**

Gracias al apoyo del resto del equipo, se seleccionaron **cinco temas que respondieran a la pregunta de la serie animada** ¿Por qué los astrónomos quieren usar Alma? Capítulo a capítulo se desarrollan temas sobre el espectro electromagnético invisible, resolución y sensibilidad, detección de moléculas complejas, galaxias lejanas y lo que ocurre al interior de frías nubes de polvo.

Esta serie estará disponible además en l**os canales regionales de la operadora de TV cable VTR (Arica TV, Calama TV, VIVE Chile Elqui, Quintavisión, Sextavisión, TV8, Vértice TV, ATV Valdivia), el canal de Youtube de VTR, y por Video On Demand (VOD)** a partir del 15 de septiembre.

En Alma, ya están trabajando para una nueva temporada 2018 de #WAWUA.

Comentarios
Cargar comentarios

Tags
ALMA Observatorio

AHORA EN PORTADA

NACIONAL
“Operación Huracán”: Subdirector de Carabineros inicia sumario en Temuco

POLITICA
Ministro Undurraga frente a DC: “Estoy dispuesto a competir por la presidencia del partido”

POLITICA
Piñera llega al lago Ranco y alista nominación de cargos pendientes

POLITICA
Víctor Pérez, senador de la UDI: “Es mal camino pelear el cariño del presidente Piñera”

NACIONAL
Caval: ex director de Obras es condenado por cohecho

NACIONAL
Ennio Vivaldi: “Quiero seguir siendo el rector de la Universidad de Chile”

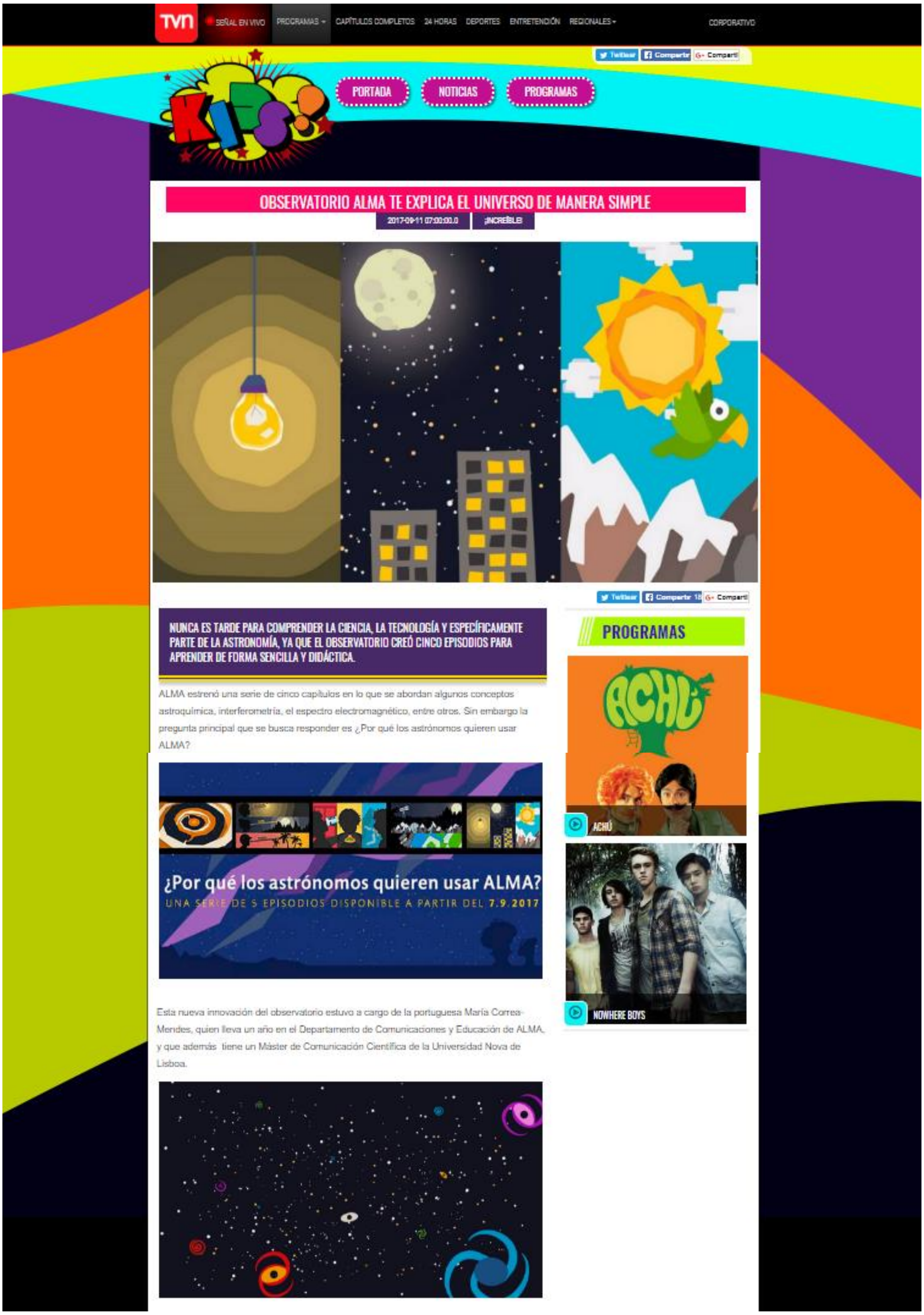
MUNDO
Las cartas de la oposición venezolana para enfrentar a Maduro

REPORTAJES
Manifiesto de Leo Caprile: “He escuchado sobre episodios de acoso sexual en la televisión”

MUNDO
Atentado en capital afgana deja casi 100 muertos

NEGOCIOS
Codelco tiene los sueldos más altos entre ejecutivos de firmas estatales

3.2. Televisión Nacional de Chile (**TVN**) – Chilean public television broadcaster**:** *"Observatorio Alma te explica el universo de manera simple".* **Published:** 11th of September 2017



[redacted]

El primer video se llama "ALMA observa lo invisible" y ya está disponible en las redes sociales del centro astronómico. Los próximos episodios se publicarán todos los jueves y también serán transmitidos en el sitio web del ALMA.

[redacted]

3.3. Las Últimas Noticias (LUN) – Chilean daily tabloid newspaper: *"ALMA revela sus secretos en videos cortitos y sencillos".* **Published:** 8th of September 2017

Las Últimas Noticias

26 EL DÍA

Viernes 8 de septiembre de 2017 / Las Últimas Noticias

El primer episodio es sobre los telescopios

ALMA revela sus secretos en videos cortitos y sencillos

Cinco animaciones, de dos minutos de duración, explican conceptos de alta complejidad astronómica.

IGNACIO MOLINA

El observatorio astronómico ALMA lanzó este jueves una serie de cinco animaciones que buscan explicar la siguiente pregunta: ¿por qué los astrónomos quieren usar ALMA? Son episodios cortitos, de dos minutos de duración, que usted podrá verlos semana a semana a través del sitio online del observatorio (http://www.almaobservatory.org)

Tanto los textos como las ilustraciones fueron hechos por la portuguesa María Corrêa Mendes, licenciada en Biología Celular y Molecular, quien intentó explicar de forma "simple y didáctica" conceptos de alta complejidad astronómica. "Para eso conté con ayuda de los astrónomos que trabajan en ALMA. Ellos me ayudaron a entender los conceptos y a poder enseñarlos. Dos de ellos, además, se ofrecieron para hacer las voces de los videos", cuenta María, de 23 años.

La portuguesa, magister en Comunicación Científica de la Universidad Nueva de Lisboa, no puede detallar todos los videos, pues quiere que sean una sorpresa, pero sí explica el primero de la serie, titulado "ALMA observa lo invisible".

Dice: "En el universo existen muchos tipos de luz, como la infrarroja y la ultravioleta. Y nosotros, al observar el universo, sólo podemos ver un tipo, la que los científicos llaman luz visible. Pero el telescopio ALMA puede ver otro tipo, las ondas de radio; y como tal, ofrece la posibilidad de descubrir cosas en el espacio, como el nacimiento de estrellas, donde hay mucho polvo que impide el paso de la luz visible".

Otros temas que usted podrá apreciar en las animaciones, adelanta María, serán sobre galaxias lejanas o los fenómenos que surgen al interior de nubes de polvo galáctico. El universo a dos clicks de distancia.

ALMA

Animaciones y textos fueron realizados por la portuguesa María Corrêa Mendes.

ATTACHEMENT 4. FACEBOOK POSTS EXAMPLES

4.1. Post in "Observatorio ALMA"

4.2. Post in "ALMA Observatory"