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# High-mass star formation

**MEETING REPORT** Pamela D Klaassen and Joseph Mottram report on a workshop at the University of Leiden which discussed the formation of high-mass stars from large to small scales in the era of Herschel and ALMA.

High-mass stars are key ingredients for several astrophysical processes, from stirring the gas in their surroundings to forming the heavy elements. They are key drivers of the evolution of galaxies and it is their light that we use to study the distant universe. However, to date, we still do not understand how they form. In January 2013, a workshop was held at the Lorentz Center in Leiden to discuss future research plans in this field. Theorists, modellers and observers came from all over the world, with the majority based in the EU. The aim was to provide a platform for the community to discuss future goals within a collaborative environment.

High-mass stars are those more massive than about 10 times the mass of the Sun. They are rarer than their lower-mass counterparts, and their formation timescales are so short that they are already on the main sequence by the time they are visible at optical wavelengths. Add to this the increasing complexity arising from the clustered environments in which they form, and it is clear that high-mass star formation is a much more complex problem to tackle than isolated low-mass star formation. While great strides have already been made, in order to move the field forward we need to combine detailed studies with understanding of global (galactic) properties. The unprecedented sensitivities of the Herschel space satellite and the Atacama Large Millimeter/Sub-millimeter Array (ALMA) provide us with the tools to do this properly.

The processes involved in the formation of high-mass stars happen deep within a dense

core of material. Observing these processes requires observing the dust and gas at long wavelengths, from radio to far-infrared. The combination of high spatial resolution and high sensitivity with a fast mapping speed has allowed Herschel to identify and study large numbers of protostars and young stellar objects. Sampling the peak of the spectral energy distribution of these sources, Herschel is revealing the intricate nature of star formation and the impact it has on its environment. With ALMA recently inaugurated and moving rapidly to full operations, we will soon be able to probe high-mass star formation at unprecedented resolution and sensitivity. This will provide a wealth of new insights into high-mass stars in our galaxy and throughout the universe.

## Current research

The goal of the workshop was to bring the community together. Talks about current research included topics from individual protostars to the impact of galactic-scale processes, looking at the properties of the gas as well as the dust. Interspersed in these talks was plenty of time for discussions in both large and small groups. There were productive discussions identifying the important questions about high-mass star formation that ALMA is well suited to address, and avenues which will require large-scale, coordinated effort to push forward.

Specifically, we explored the possibility of observing a common species among different science cases. For example, methyl cyanide seemed a suitable candidate: its radiatively

**1: This giant molecular cloud W3 is about 6200 light-years away in the Perseus Arm of the Milky Way and shows a stellar nursery. Intense radiation from the highest-mass stars heats the gas and dust, shown here in blue. This false-colour image combines Herschel infrared bands at 70  $\mu\text{m}$  (blue), 160  $\mu\text{m}$  (green) and 250  $\mu\text{m}$  (red). (ESA/PACS and SPIRE consortia, A Rivera-Ingraham and P G Martin, Univ. Toronto, HOBYS Key Programme [F Motte])**

decoupled K-ladders provide an excellent diagnostic of temperature, and there are many transitions available throughout each of the ALMA bands. This will build on the science from each individual study, and aid intercomparison between observations across a wide range of parameters and projects.

The organizers were very pleased with the enthusiastic and constructive discussions during the workshop. We established several open working groups to act as a focus for the exchange of information about ALMA proposals and projects, and to aid in building future collaborations. This will enable the European high-mass star formation community to go forward in a coordinated fashion, and will ensure a greater legacy quality to the data that we will obtain over the next few years. ●

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