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ROBERT GROSSETESTE: THE GEOMETRY TO SOLVE THE COMPLEXITY OF THE WORLD

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Abstract
Robert Grosseteste, an English philosopher and scientist, Bishop of Lincoln, is considered as the founder of the scientific thought in medieval Oxford. During the beginning of the XIII century he wrote several scientific papers concerning light and its propagation, where he based the discussion of some phenomena on the use of geometry. Here we will translate and discuss one of his scientific treatises concerning light, entitled De Lineis, Angulis et Figuris, seu Fractionibus et Reflexionibus Radiorum. Since to Grosseteste, the propagation of light had the main role in the creation of the world, the use of its geometry becomes a method to solve the complexity of the physical world. Here we will find an interesting text, where phenomena concerning the intensity of reflected and refracted light seem well-posed, even when compared with the Fresnel theory.

Introduction
Robert Grosseteste was an English scientist and philosopher of the Middle Age. He was born into an Anglo-Norman family in the county of Suffolk in England. He became Bishop of Lincoln from 1235 AD till his death, on 9 October 1253. Considered one of the most prominent and remarkable figures in thirteenth-century, he was a man of many talents: commentator and translator of Aristotle and Greek thinkers, philosopher, theologian, and student of nature [1]. Besides these scholar studies, as a bishop, he focused his energies on rooting out abuses of the pastoral care.
Grosseteste wrote several short works on physics. He is considered one of the three Oxonians that played a relevant role in the revival of Optics in the thirteen century [2]. After him there were Roger Bacon and John Peckham, who considered Grosseteste as an inspiration for their scientific developments. Generally, Grosseteste is considered as a thinker that played a key role in the development of scientific method. In [1], it is reported that A.C. Crombie [3] describes Grosseteste as the first in the Latin West to develop an account of an experimental method in science, giving a special importance to mathematics in explaining the physical phenomena. However, the Crombie's claim that Grosseteste used experimental methods has been subjected to a considerable debate. In fact, in Ref.1, it is told that the Grosseteste's method was quite different from that of a controlled experiment. Grosseteste, in his writings, derived his conclusions on the basis of a mix of considerations, appealing to authorities such as Aristotle or Averroes, and on everyday observation (the Latin "experimentum"). He made use of thought experiments and certain metaphysical assumptions, such as the assumption of a principle of "least action", that we will find for instance in reading the treatise which is the subject of this article and the De Iride, another of his scientific treatises on the propagation of light. However, the empirical observation remains the main factor for his discussion of nature, sometimes gaining well-posed conclusions on phenomena. However, he is far from employing an experimental method involving a controlled experiment: we can assume that his experimental "verification and falsification" was as a first step towards the modern method.
As it is told in [1], reporting the studies of Ludwig Bauer [4], Grosseteste gave a relevant role to mathematics in attempting to explain the physical world. In his treatise On Lines, Angles

and Figures, Grosseteste remarks that "the consideration of lines, angles and figures is of the greatest utility since it is impossible for natural philosophy to be known without them …. All causes of natural effects have to be given through lines, angles and figures, for otherwise it is impossible for the reason why, the propter quid, to be known in them" [1,4]. In the treatise, On the Nature of Places, a continuation of the treatise On Lines, Angles and Figures, Grosseteste remarks that "the diligent investigator of natural phenomena can give the causes of all natural effects, therefore, in this way by the rules and roots and foundations given from the power of geometry". Undoubtedly, Grosseteste saw a key role for geometry in the explanation of natural phenomena. As remarked in [3], he was deeply concerned with a detailed investigation of natural phenomena: it was his attitude of mind, and his emphasis on the importance of geometry and mathematics, that was a stimulus to thinkers in the Oxford of the fourteenth-century, who were developing the beginnings of a mathematical physics, studying in particular light and optics.
Grosseteste imagined the light having even a fundamental role in the creation of the world [5]: it was the light propagating in the space, dragging matter together, to originate it from a point at the beginning of times. The light is then the central subject in the Grosseteste's thought, such as the optical phenomena describe by geometry. We can tell therefore that his approach to the complexity of the physical world was based on the assumption of some models, models that could be solved with geometry; however, the solutions of them are always subjected to the experience of occurring phenomena.

Geometrical optics

As previously told, Grosseteste is usually referred for his use of geometry in optics, for instance in the reflection and refraction of light. However, besides the geometry, A.C. Crombie in [6] is remarking that Grosseteste developed an analysis of the powers propagated from the natural agents. This analysis is found in four related essays written most probably in the period from 1231 to 1235 AD. Two treatises on optics are the De Colore [7] and the De Iride [8]: another treatise is that entitled De Lineis, Angulis et Figuris seu Fractionibus et Reflexionibus Radiorum. Crombie shortly commented this treatise in such a manner: according to Grosseteste "the same power produced a physical effect in an inanimate body and a sensation in an animate one. He established rules for operation of powers: for example the power was greater for shorter and straighter the line, the smaller the incident angle, the shorter the three-dimensional pyramid or cone; every agent multiplied its power spherically. Grosseteste discussed the laws of reflection and refraction (evidently taken from Ptolemy) and their causes, and went on in De Natura Locorum to use Ptolemy's rules and construction with plane surfaces to explain refraction by a spherical burning glass" [6]. Let us remark however, that Grosseteste used the optics of Alhazen and Alkindi [9], besides that of Ptolemy.
What Crombie is telling about power of rays is stimulating to analyze the Grosseteste's treatise. Let us read it subdivided in several sections. This subdivision is more convenient for the following discussions which are specific for the considered section. The Grosseteste's text is printed in *Italic*: it is my translation from the Latin source in Ref.[10]. We will see that the discussion on the power of reflected and refracted rays is interesting and seems well-posed when compared with the rigorous approach by Fresnel reflectance formulas.

The Grosseteste's Lines, Angles and Figures

1 - The utility of considering lines, angles and figures is huge, because it is impossible to know the philosophy of nature without them. They are valid for the entire universe and, unconditionally, for all its parts. They apply in connecting the properties, such as in straight and circular motions. And they apply in action and passion (reaction), and this is so, whether in the matter or in the capacities of perception; and this again, whether in the sense of sight, as

it is occurring, or in any other sense in the action of which, it is necessary to add other things on that which is producing the vision.
2 - Since, then, we have discussed elsewhere of those things pertaining to the whole universe and to its parts in an absolute sense, and of those which are consequent to straight and circular motions, now it must be said something concerning the universal action, as it receives a lower nature; this universal action is the subject able of various features, so far as it happens descending to act in the matter of the world; moreover, other things can be questioned, that can educate us to proceed ad majora.
3 - Therefore, all the causes of the natural effects must be given by lines, angles and figures, because it is impossible to know in another manner the "propter quid" in them. It is clear the following: a natural agent propagates (multiplies) its power from itself to the patient, a person or thing that undergoes some action, that is, whether its acts on sense or on matter. This virtue is sometimes called "species", sometimes "likeness", and it is the same, in any way we call it; and the same thing is instilled in the sense and in the matter, or vice versa, when heat makes warm to the touch and gives itself to the cold body.
4 - For, it does not act through deliberation and choice; and therefore in one way it acts, whatever it is occurring, whether it is a perception or something else, animated or inanimate. But because of the diversity of the objects of action we have different effects. Moreover, in the perception, this received power produces, in some way, a spiritual and noble effect; on the other hand, when acting on the matter, it produces a material effect, such as the sun produces, through the same power, different effects in different objects of its action. For it harden the clay and melts the ice.
5 - The power, then, produced by a natural agent comes along a shorter line, and it is more active, because the patient receiving it is less distant from the agent, or along a longer line, and then it is less active, because the patient is more distant. However, the power comes directly from the surface of an agent, or with mediation. If it comes without mediation, it will come by a straight line, or by an oblique line. If, however, it comes by a straight line, then there is a stronger and better action, as Aristotle assumes in V Physics, because the nature acts in the shorter way, which is possible. But the straight line is the shortest of all, as he says in the same book.
6 - Similarly, a straight line has equality and no angles; but equal is better than unequal, as Boethius tells in his arithmetic. But nature acts in the possible shorter and better way, and therefore it works better on a straight line.
7 - Similarly, every compact power is stronger in its operations. But, the greater union and unity is in a straight line rather than in distorted line, as stated in V Metaphysics. And then an action works stronger on a straight line.
8 - But the straight line falls either at equal angles, that is, it is perpendicular to the surface, or at unequal angles. If it falls at equal angles, the operation is stronger for the three abovementioned reasons, because the line is shorter and equal and its power comes more uniform through it to the parts of the patient, person or thing that undergoes the action.
9 - A line, however, is falling down with equal angles on a body perpendicularly, that is with right angles, when it falls on a plane; when it falls on a concave body, at acute angles; but when it is over the sphere, at angles larger than right angle. This is shown as in the following, because, if a line is drawn passing through the center of a sphere, it makes a right angle with the line of contingency (tangency), and the line of tangency makes with the sphere on both sides the angles of contingency; then, the line falling on the sphere makes two angles with its surface, each angle larger of the right angle, being the sum of the right angle and the angle of contingency. Thus when the power falls, with angles which are not only equal, but right, then it would seem the action to be very strong, because there is complete equality and uniformity.

10 - If, however, it is not a straight line but it is a curve, nevertheless, not circular, because a natural agent does not produce its own strength according to a circle, but according to the diameter of the circle for the sake of brevity, it is manifest that such a line will have some angles. And this will not occur, as long as there is a single medium, or while there only one body; but it is necessary that there are two media, whence in the first the power is propagated along some straight lines, in the second along other lines.
11 - But this can be only in two ways: or that the body of the patient is dense, so as to impede the transit of power, especially in regard to our perception, and then it is said we have a reflected line, which is turning back the power, or the body the light is passing through is rare, which allows the propagation of power. If we have the first case, then we have the ray falling on a dense body, it falls with equal angles, that is, perpendicularly to the body, or with unequal angles, that is inclined. If we have the first manner, then it returns into itself through the same path, along which it arrived to the body. The reason of this is due to the following, the line falling on the body makes such an angle, as it is the angle made by the reflected line.
12 - And therefore it is proper that it is reflected at the same angle, upon which the ray travelled and return by the same pattern. For if it were redirected with another angle or following another pattern, turning to the left or to the right, it would be impossible that the return forms an angle equal to the angle of incidence; it would be larger or smaller.
13 - If it falls not perpendicularly, then it comes back along such pattern, able to make an angle with the surface of the resisting body equal to the angle of incidence, namely, the angle which is made by the incident line with that body, for the argument already mentioned. Generally speaking, the angle of incidence and the angle of reflection are equal, which is to be assumed now.
14 - Since these are the two modes in which reflection may happens, it is to be understood that the reflected power into itself, because of a doubling of the power in the same place, is stronger than the reflected power in another path. Nevertheless, and this is in the essence of reflection, the action of the reflected ray is weaker, when there is the reflection in the same path, since each reflection is weakening the power, and this precise reflection, making the power to have a complete deviation of 180° from the straight prolongation of the incident ray, that is the direction the ray would have if it were to pass through the body, is highly weakened; and this is for the ray, which is in on the same path on which it came from. And then the path is totally contrary and opposed to the incident one, as it is to be.
15 - When we have a reflection from some bodies polished to have the same nature of mirrors, then it is the best reflection and stronger action; but when reflection happens on rough bodies, the species, that is, what is making the appearance of an object to the sight, are dissipated, and the action is weak. The reason is given by Averroes, the Aristotle's Commentator, in his discussion on the sound, saying that the parts of a body surface smooth and polished, for its equality and uniformity, all together are concurring into a single action in the reflection of the species; and therefore the whole power, as it came, is reflected back from the polished body. But when the parts of a rough body are unequal, those parts protruding are reflecting the species first, and therefore there is not an agreement of the parts in a unique action, and for this reason we have a dispersion of this species randomly, and this is not a good operation.
16 - When the reflection is obtained by means of some concave bodies, the action is stronger, than when the bodies are plane or convex, and this happens because the rays reflected by a concave surface converge together; this does not happens for the other cases.
17 - Indeed, if the medium encountered by the light is not impeding the transit of power, a ray incident at equal angles, that is perpendicularly, maintains the straight line and is the strongest ray. But the ray, which is incident at unequal angles, that is inclined, deviates from the straight line that the ray had in the first medium and that it would still have if the medium were homogenous. This deviation is called refraction of rays.

18 - The refraction is twofold: when the second medium is denser than the first, the ray is refracted to the right and passes between the prolongation of the direction of incidence and the perpendicular drawn from the point of incidence in the second medium. When the second medium is rarer, the ray is refracted to the left, receding from the perpendicular beyond the prolongation of the incident ray. And since these are the facts; then we need to understand the reason why the power incident along a refracted line is higher that the power along a reflected ray, this happens because a refracted line little deviates from the prolongation of the incident ray, which is the strongest, and the reflected line largely deviates in the opposite direction, and then the reflection is weakening the power more than refraction.
19 - About the power of the two modes of refraction we can tell that the power refracted to right is greater than that refracted to left, since this power, that to the right, is closer the perpendicular to the interface, whether this is the perpendicular line drawn from the incidence point, or a line drawn from the agent, from which the perpendicular line and the refracted line have their origin.
20 - Besides these three fundamental lines, there is a fourth accidental line, along which an accidental and weak power moves. Which, indeed, does not come directly from an agent, but is coming from a power propagated by any of the three abovementioned lines; in such a manner, from a ray entering a window, it comes, by chance, the light to all the corners of a house. However, this power is the weakest one, because it does not come directly from the agent, but it is separated from the power of the agent, in a straight line, or reflected or refracted. These facts we told about lines and angles.
21 - About the figures, there are two kinds of them that we have to consider here. One of these is suitable for propagation of power, namely the sphere. And this for the following reason: every agent emanates its power spherically, since it does all around and in every direction (diameter): upwards and downwards, ahead and aback, right and left. And this is shown by the manner in which it is possible to draw a line in a certain direction from an agent located at the center, and in all directions from all the different positions, and therefore it is proper to use that spherical figure. And thus, in agreement with what the Commentator (Averroe) says in the (Aristotle's) De anima. Also, wherever we put the sensor to receive, we can feel such an agent at a proper distance; however this happens only by species or by the power coming from the agent. So the power is propagating everywhere.
22 - Another figure, however, is required for the natural action, that is, the pyramidal one: since, if the power is coming out from a part of the agent and ending onto another part of the patient, and so on for all, so that it always happens that the power from a part of the agent comes to a sole part of the patient, the action will never be strong or good. But the action is complete, when the power of the agent comes from all the points of the agent or from its whole surface to every point of the patient. But this is impossible, except under the pyramidal figure, because the power that comes from each of the parts of the agent are concurring in the cone of the pyramids and are gathered together and then they all are able to act more strongly upon the part of the patient where they are condensed.
23 - Therefore, an infinite number of pyramids can come out from a surface of an agent, which pyramids have the same basis, namely, the surface of the agent, and there are so many cones as are the pyramids, and they fall into different points of the middle or on all sides of the patient, and there can be an infinite number coming out from a side, shorter and longer. But those cones, which are equal in length, and of the same brevity, they do not have different features, because they act in the same manner, inasmuch it is concerned its own part, though it can be a variety of features on the part of the recipient matter.
24 - But when one pyramid is shorter than the other, and they come out by the same agent, it is pretty difficult to tell, whether is the cone of a shorter pyramid acting more on a patient or not. And it is necessary to suppose that the shorter pyramid acts more, because its cone is less

distant from its source, and for that reason there is to be found more power, than in the longer pyramid and then the patient is more closely connected to the agent and therefore strongly altered by its power.
25 - Besides, if the rays, which are in the bulk of a shorter pyramid, that come from the right side, are prolonged besides the vertex, uninterrupted and straight, they will form smaller angles with the left beams, which are from the bulk of the pyramid, than the similar rays which are from a longer pyramid, as it is clear from the 21th section of first book of Euclid geometry, and also by the common sense. And in the same way, the rays coming from the left of the pyramid, which continues beyond the vertex, uninterrupted and straight, are closer to the rays of the right side, coming from the bulk of the pyramid, than the consimilar rays of a longer pyramids.
26 -Then, when every congregation and union is more active, the cone of a short pyramid acts more and alters the patient more than a longer cone. However, we could object rationally, that, when from all the surface of an agent, the power is coming in a longer pyramid, we have there more power, because the cone is more acute than short, and all the power is condensed for a large operation, and here it is also to add that the rays of a longer pyramid are relatives to the rays of the agent, rays drawn perpendicularly from the ends of the diameters of the agent, and then they are stronger, because a perpendicular progression is the strongest: it can be said, that these reasons are stated very well, far enough, and so forth, unless some stronger reasons are opposed to them that we have aforesaid. This is the end of the treatise by a Lincolnian on the reflections and refractions of rays.

Notes to the text
1 – This is Incipit of the treatise. Let us report, after these strong Grosseteste's words what A.G. Padgett is telling about Grosseteste in [11]. "Even as he translated and interpreted Aristotle, Grosseteste placed Aristotelian natural philosophy in a broader Christian and Neo-platonic world view. … he was committed to a natural philosophy based upon mathematics. This emphasis derived from Platonic and Pythagorean traditions, as mediated to him through Patristic authors like Augustine. A mathematical natural philosophy is demonstrated in a number of his works, particularly works on astronomy, light, and in his treatise on geometry, De Lineis, Angulis et Figuris." As we will see in reading this treatise, it is not only a treatise on geometry, as told by Padgett, but on the geometry applied to light propagation. Padgett continues in [11] telling that in the incipit of the treatise, Grosseteste defends his mathematical approach to natural philosophy. "Notice that Grosseteste wants to use geometry, which was long a key tool of astronomers, within natural philosophy. This is a decisive step in the history of Western science, although Grosseteste was not alone in making it." [11].
2 – In a translation by E. Grant [12], we find that here Grosseteste is proposing a universal action descending in the lower world, according to an Aristotelian view of the universe. "Ad majora" is a Latin wish we can give to a person, to have greater things, that is, success and satisfaction.
3 – In this section the find the "species". Species in Latin means: seeing, view, look; sight; but also external appearance; general outline or shape. Then the species is that feature of the power of light which allows perceiving the shape of an object. In the De Iride [8], we found the "quid", that is the effect, or the phenomenon, the physics needs to describe, and the "propter quid", which is instead an answer given by the research, on the causes of the phenomenon. And here Grosseteste is telling that without the geometry we are not able to answer. As previously told in discussing the Incipit, Grosseteste is claiming the necessity to use mathematics and geometry to explain physics.
6 – Concerning this section, we can repeat what Grosseteste is telling in De Iride [8]: "And the same tells us that principle of the philosophy of nature, namely, that every action of the nature

is well established, most ordinate, in the best and shortest manner, as it is possible." This principle is aiming to find a figure in the complexity of the world.
8 – In this section, Grosseteste is discussing what is happening when light falls onto a surface. And therefore he is talking about illumination. And here then, it is suitable to remember the cosine law of illumination, which is a geometric relationship between the illuminance of a surface and the angle of incidence of the illuminating rays. If a source of light is point-like, the illuminance that it produces on a surface depends on intensity, distance and angle of incidence. Then, let us consider the intensity I of the light in a particular direction from the source: the light travelling a distance d falling with an angle θ, measured from the normal to the surface, has an illuminance E given by $E = I \cos\theta/d^2 .= I \cos^3\theta/h^2$, where h is the perpendicular distance [13,14]. The maximum illuminance is for normal propagation. Illuminance is analogous to irradiance, but is to be distinguished from the latter in that it refers only to light. A distinction is necessary between illuminance and luminance: the latter is a measure of the light coming from a surface.
9 – According to [12], the Medieval scientists regarded "contingent angles", that is the angles of tangency, as having a finite magnitude. Therefore the contingent angle is different if it is of a convex or concave surface.
10 – Of course the treatise is discussing reflection and refraction of light according to its title. And in this section we find that Grosseteste is explain that to bend the light we need several different media, so that at the interfaces the ray is broken with certain angles. This is discussed in the De Iride [8] too, where we find even a law of refraction, which tells that the angles of refraction are one half the angles of incidence. In his Latin text, Grosseteste is telling that the power "multiplies" along a straight line. And in fact, when Grosseteste talks about the light and its propagation, he imagines it as multiplying itself [15]. I translated as he imagined the propagation of light as a multiplication, more or less, as proposed by Huygens for the waves. In 1678, Christiaan Huygens proposed that each point of a luminous wavefront can be the source of a spherical wavelet. The sum of these wavelets determines the new propagated wavefront. He assumed that the secondary waves travelled only in the forward direction. And then the light is "generating" itself, in the sense of propagation. May be, Grosseteste imagines a similar mechanics, without waves, however.
11 –.Here the law of reflection, telling the incidence and reflected angles are equal.
14 – In this section, Grosseteste discusses the "doubling" of the power (in the Latin text, Grosseteste is proposing "gemination"). A possible interpretation can be the following: let us consider a ray of light normally incident on a surface and the reflected ray, radiated back into the half-space of the incident ray. It means that in the volume occupied by these rays, which is the same, we have a "doubling", a superposition of power. In any other case, that is, when the incidence is oblique, a certain volume of the space can be occupied just by the incident or by the reflected ray. Grosseteste continues discussing the power of the reflected rays as depending on the angle of incidence. Here is quite useful the suggestion of a deviation of 180° given in Ref.12. What is told by Grosseteste is in agreement with the fact that the light falling at an angle on a surface tends to be increasingly reflected as the angle of incidence increases, and the transmission reduced. For a normal incidence, in fact, we have the largest amount of transmitted power and the smallest reflected. Usually, the behavior of the reflected light with the angle of incidence is studied according to polarity. The Maxwell's equations allows the derivation of the Fresnel equations (see for instance, the Fresnel laws of reflection as discussed by a chapter in the first volume of the Feynman Lectures on Physics), which can be used to predict how much of the light is reflected and refracted. On a specular reflection then, we have that the fraction of the reflected light increases with increasing angle of incidence θ. The Fresnel reflectance for metals and dielectric materials is very different. For a metal such as aluminum, the reflectance is always above the 85%. For a glass having a refractive index of

n=1.5, the reflectance is of only 4% at normal incidence, but 100% at grazing. “This effect, in fact, is what makes polished metals look like metal, and polished glasses not look that way. It's also why it's hard to comb your hair in a shop window; you are looking at the angle of minimum reflectance.” [16].
15 – Here Grosseteste is distinguishing between specular and Lambertian surfaces. Very interesting is the fact that Grosseteste is using an analogy with the sound waves, telling that Averroes, the Aristotle’s Commentator, studied the sound propagation and the role of irregular surfaces in break down the reflection of it.
17 – For a normal incidence we have the largest amount of transmitted power. The transmitted power is reduced increasing the incidence angle.
18 – To have an agreement of the last sentence with what was previously told on the intensity of transmitted and reflected light, we have to assume that Grosseteste is considering a normal incidence or an incidence at small angles.
22 – That is, instead of a disordered analysis of the propagation of some rays, it is better to consider the solid angles.
25, 26 – In my opinion, Grosseteste used the solid angles to analyze emitted and received power. However, without any diagram illustrating his proposal it is difficult to appreciate this part of the treatise.

Conclusions

After the notes to the text, it is better to stress once more that what Grosseteste is telling about the power of the reflected and refracted light is in qualitative agreement with the Fresnel formula of reflection and refraction. The discussion of the illumination of surfaces is quite good too.
Grosseteste’s texts had no diagrams or mathematics. However, let us remember that to have Cartesian frames or differential calculus people had to wait the XVII century. We can agree with Ref.1, that claims that Grosseteste gave a “special importance to mathematics in attempting to provide scientific explanations of the physical world is on a stronger footing”, as we can find in the opening of On Lines, Angles and Figures. In the treatise, On the Nature of Places, which is its continuation, Grosseteste sums up the preceding text with the remark that “the diligent investigator of natural phenomena can give the causes of all natural effects, therefore, in this way by the rules and roots and foundations given from the power of geometry” [1,4].
Ref.1 continues telling that at the basis of the reasoning on light, there was Grosseteste’s view that natural agents act by the multiplication of their power or species, a view developed further on by Roger Bacon. However, let us note that if we consider the “multiplication” as propagation, this could be a sort of propagation of light as Huygens imagined several years after. “Grosseteste holds that the intensity of operation of the natural agent will be a matter of its distance from what it acts upon, the angle at which it strikes it, and the figure in which it multiplies its operation, this being either a sphere or cone. He establishes certain rudimentary rules to this effect, such as that the shorter the distance, the stronger the operation”: this is told in [1]. As we have seen from reading Grosseteste’s treatise, some observations on the power of transmitted and reflected light are more that rudimental. Probably he found some comments in Arab texts, or even experimented about them.
After reading his treatise, we can overall conclude that Grosseteste aimed to describe the world and solve its complexity, using the geometry. Let us repeat the Padgett’s comment, that Grosseteste saw the natural philosophy based upon mathematics, and that he continuously stressed his mathematical approach in several of his treatises. Grosseteste wants to use “geometry, which was long a key tool of astronomers, within natural philosophy”, a decisive step in the history of Western science.

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