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# WITELO AND ALHAZEN THE MOST PROMINENT PERSPECTIVE SCIENTISTS OF THE MIDDLE AGES

As early as in ancient times people were interested in the problem of perspective and a way of picture creation in human eye. As Witulski [8] writes 'Getting to know the properties of light, which are common to our senses in countless phenomena and rules, was for ages the scope of interest of many thinking people who were not different to nature and liked to find out causes and rules. Therefore, we can see that nations which respect disciplines of science with special passion to this branch of physics which is called optics were working on and writing many treatises.'

All written sources available to the author state that after first period of interest in optics in ancient epoch there was a long break. Only at the end of the $9^{th}$ or at the beginning of the $10^{th}$ century the first significant work connected with the topic of perspective appeared – 'De aspectibus' (later known as 'Optica' from Greek) by Alhazen, an Arabic scientist. The author is criticised for his lengthy style and complexity in the way of explaining things but it is undoubtedly the work, which compiles all current information on optics, and it started a new wave of interest in perspective.

Not only had the author compiled all the knowledge written by his predecessors but also discussed new issues. He described eye structure for the first time and wrote about a way of picture creation in an eye. Seen objects were accepted as sources of light. From each of their points rays of light are drawn as straight lines in all directions [8]. Between an eye and a seen object a light cone is created, with a vertex being placed in the eye and a base on the seen object [3].

Among other Arabic scientists who dealt with the nature of light from the discussed period D. Folga – Januszewska [7] mentions also Al. – Kindi. His considerations, however, were not made known and are not commonly acknowledged.

Next important publication, which appeared later, in the second half of thw $12^{th}$ century is 'Perspective' by Witelo.

The very personage of Witelo is not known or appreciated enough in Poland. As the authors of Polish translation of the $1^{st}$ and $2^{nd}$ books of 'Perspective' write: 'The author of once important textbook in later centuries appears only in laconic references in science publications.'

As to the Polish origin of Witelo there should be no doubts since in the first words of his introduction to 'Perspective', including dedication to Wilhelm from Moerbeke, he writes: „Veritatis amatori Fratri Guilielmo de Morbeta, Vitello filius Thuringorum et Polonorum”. In X 74 theorem Witelo repeats this bit of information, namely: 'in terra nostra, scilicet Poloniae habitabili, quae est circa latitudinem 50 graduum' (in the land inhabited by us i.e. Poland, which is located on the 50 degree of latitude). [3] He finishes his work with words: *Vitellonis, filii Thuringorum et Polonorum, opticae finis.*

J. Burchardt's research showed that Witelo's mother was Polish and his father German who came to Silesia from Thuringia[3].

The date of Witelo's birth and death is not exactly stated. C. Baeumker gives 1230 – 1270, and A. Binkermajer  1230 – before May 1314, J. Burchardt states 1237 – after1281 [3].

The form of first name of the author of 'Perspective' was also a puzzling issue. For many years Latinised form of a name Vitellio and Vitello were used and we find them in Latin editions of his work. J. Sołtykowicz accepted form Vittello as a Latin translation of a Polish surname and translated it into Polish as Ciołek (vitellus, vitellum – cielątko).    In the 19 [th] century on the basis of manuscripts and other historical documents it was stated that the only correct form of the first name of the author of the treatise is Witelo [3].

Witelo started his primary education in Wrocław. When he was 15 he went with Silesian Prince Wodzisław's suite, the son of Henryk Pobożny, to Paris to study and he spent 6 years there. After a few years spent in Poland, in 1262 he went to Padwa with Prince's suite again to study canonical law. From 1268 Witelo was at Pope's court in Viterbo where he met Pope's confessor, Dominican friar from Brabant, Wilhelm from Moerbeke who encouraged him to write 'Perspective' and who translated Greek works to Latin for him.

As J. Burchardt supposes in 1273 Witelo probably returned to Silesia with Czech deputies where in 1275 he received prebenda as Wrocław canon from Prince Henryk Probus in Oleśnica Śląska. Then Henryk Probus sent Witelo to Viterbo to Pope's court. After Czech king's Ottokar's defeat in the war with Rudolf, German emperor, Witelo moved to emperor's service. Next year i.e. 1281 he was relieved from the service at his own request and took the habit of Premonstratensians in Vicogne [3].

Witelo's 'Perspective' was written in about 1270, although the exact date is a controversial issue. The first edition of this work was published in 1535 under the title *Vitellionis Mathematici doctissimi περί όπτικης id est de natura, ratione et proiectione radiorum visus, luminum, colorum atque formarum, quam vulgo perspectivam vocant. Libri X. Norinbergae apud Jo. Petreium Anno 1535. Nunc primum opera Mathematicorum praestantissimorum dd.Georgij Tanstetter et Pietri Apiani in lucem aedita* edited by G. Tanstetter and  P. Apian.

Second edition with no changes appeared in 1551.

Third edition and the last one were under the title *Vitellonis Thuringopoloni opticae libri decem. Instaurati, figuris novis illustrati atque aucti infinitisque erroribus, quibus antea scatebant, expurgati, a Federico Risnero. Basileae 1572.*fol.. They were published with Alhazen's Optics by F. Risner. He made many corrections and supplements which were not always right, as the editors of the Polish edition [3] claim.

When writing his treatise Witelo must have had Latin translations of 'De aspectibus' by Alhazen, 'De ponderibus' Pseudo–by Archimedes, works by Archimedes, Eutokios, Heron and Ptolemeus [3].

Witelo himself mentions only [4] 'Elements' by Euclid and treatise by Apollonius from Pergai 'On conic elements' (*Conica elementa*).

One of the biggest objections raised to Witelo is the fact that using Alhazen's work to a great extend he did not mention it.

Witelo's work is 474 pages long in folio of compact print. It consists of 10 books at the beginning of each we find short summary and compilation of all definitions and postulates (so-called petitiones i.e. known truths which do not need proofs) [8].

The first book is a mathematical foundation for the remaining nine books of a vast treatise [4]. It is a compilation of geometrical rules, which he meant to use for explanation of the successive books.

Majority of theorems and proofs are supposed to be Witelo's and the rest is taken from the above-mentioned bibliography.

We can find here definitions [4] of pole, convex line, concave line, convex and concave surface, a line normal to convex surface, normal to concave surface, intersecting circles, great and small circles of sphere, equal spheres, parallel spheres and circles, tangent

and intersecting spheres, plane tangent to a sphere, denominator of proportion and compound proportion.

Then he moves to theorems. As Unguru writes they are both planimetric and stereometric, they deal with features of parallel and perpendicular lines, harmonic division of a segment, ratio and proportions, triangles, rhomboids and circles, basic features of planes and lines, intersection of two planes, orthogonal and scew lines of planes. They deal with angles resting on arcs and central angles, cords of circles and angles between two cords intersecting circles inside and outside, angles between a tangent line and a cord, angles tangent to a circle and circles intersecting each other. Some theorems deal with a sphere, namely, great and small circles, plane tangent to a sphere, spheres concentrically tangent and intersecting. Further on he discusses cones and cylinders and their sections.

In the second book Witelo proceeds to optics. Among the most important issues discussed here we can mention his considerations on light rays - light goes through straight lines instantaneously without including time (it is probably a mistake taken from Aristotle). Then the author talks about shadows, conditions of shadow creation, its shape, size and correlations from lighting and lighted body.

Third book describes composition and structure of a human eye (probably based on Alhazen without mentioning it). Belke and Kremer [3] in 'History of Nature Science' consider Ciołek as first Polish anatomist 'although he was not a doctor he described the structure of a human eye in third book of the already mentioned work and explained the impact of light reflected from external objects.'

This statement, that the process of seeing happens due to light being reflected from objects, was then quite an advance in science. Although already Alhazen wrote that light goes from seen objects to an eye and in accordance with Aristotle he considered it as not a source of light, then Euclid and Heliodor from Laryss, Epicure and Hipperch were wrong in this matter assuming that light is created by rays coming out of eye.

As Witelo proves from each point of the seen object many light rays are drawn to the eye surface but only the orthogonal one passes through. All these orthogonal lines create the cone surface with the vertex being in the centre of the eye and the pupil the base. Clear seeing is, according to Witelo, possible only along orthogonal lines, stretching from points of a seen object to eye surface, 'and from this it results that each seen thing arranges itself in eye as it is on its surface' [8].

Book four considers conditions of seeing (light, knowledge of the distance of the seen object, size, good sight, clarity of air etc.), the problem of angle of sight discussed here seems to be important for the issue of perspective (this angle according to Euclid and Ptolemy is limited to 90 degrees), correlations between angle of sight and the size of seen objects, optical illusions connected with size, shape and location. As Wituski [8] claims since Euclid's 'Optics' these were widely known theorems.

The next five books deal with mirrors, seemingly a topic not related to perspective but it is worth remembering that for Renaissance artists mirror plays important role as the one reflecting perspective phenomena and control of a painted picture [1].

The last, 10 th book deals with meteorological phenomena.

When Witelo's 'Perspective' was being written there had already existed or were appearing other treatises discussing optics. To a large extent they resulted from scientists' interest in philosophy of nature [3] K. Bartel [2] mentions an Englishman Roger Bacon (1214 – 1294) and Jan Pisanus (1240 – 1292) bishop of Canterbury, and D. Folga – Januszewska [6] Jan Peckham (1277 – 1279 –years of writing treatise 'Perspectiva communis'). Yet, J. Schubler [6] in a figure comparising the greatest perspective treatises written till 1725 mentions only Witelo and Alhazen in a period of our interest.

It is difficult to state in which direction mutual influences of particular treatises were going. The most eminent among contemporary researchers D.C. Lindberg [3] thinks that Witelo knew Bacon's treatise and was under his influence and at the same time Witelo influenced Peckham. Undoubtedly, all of the above mentioned medieval scientists were influenced by Alhazan.

It is difficult to assess unequivocally which of those days researchers had greater influence on the development of optics. Nevertheless, it can be explicitly stated that since the end of 13 [th] century both scientists Alhazen and Witelo played important role in passing optical knowledge. D.C. Lindberg [3] emphasizes that as it follows from university status in Oxford from 1431 r., Alhazen's and Witelon's treatises were obligatory set books for students and Krakow university Professor Sędziwój recommended their works as textbooks. 'Witelo's work is the most complete lecture on optics from the Middle Ages, it was used till the 17 [th] century as fundamental work in its discipline' [5].

It is known that a copy of 'Perspective' edited by Tansteter - Apian from 1535 was given to Mikołaj Kopernik in 1539 by J. Retryk. Our author's work was also in library of Leonardo da Vinci who had a favourable opinion of him and wrote about him in his 'Treatise on Painting'.

Many people gave their opinion on our scientist Erazm Reinhold (1511 – 1553) – lecturer in Wittenberg, the author of mathematical tables, Gaspar Peucer (1525 – 1602) – a doctor from Wittenberg and many others. J. Kepler, who considered him as a creator and forerunner of modern science, wrote a supplement to Witelo „*Ad Vitellionem Paralipomena quibus astronomiae pars optica traditur potissimum de artificiosa observatione diametrorum deliquorumque Solis et lunae. Cum exemplis insignium eclipsium habes hoc libro, Lector, inter alia multa nova. Tractatum luculentum de modo visionis et humorum oculi usu centra opticos et Anatomicos”.* As the authors of a Polish translation of 'Perspective' [3] state - the work of Witelo was for Kepler a symbol of past science and its embodiment, it formed compendium of the medieval knowledge on optics.

Scientists never managed to agree on the evaluation of Witelo's work. Some estimated it very highly, others thought it was only plagiarism of ancient authors and Alzahen's translated into Latin. J. B. della Porta a mathematician and an astrologer claims that Witelo 'was always wrong when he moved away from others' and in his treatises *„De refractione optices parte”* published in Naples in 1592 he called Witelo 'Alhazen's monkey'.

F. Risner, in spite of his sceptical attitude to 'Perspective' states: 'If we are to choose as the creator and author the one who gave form and spirit to skills, the most reasonable would be to consider Witelo as the creator of optic science'. As the authors of the Polish translation of the work state in order to see the differences and progress of thoughts in Witelo against *„De aspectibus”* by Alhazen both books must be studied very carefully.

K.F. Wojciechowski notices very pointedly that in science not only first formulation of a theorem and its proof is important but also general and correct accuracy of theorem formulation and the way of proof conduct. More general and correct formulation of a theorem, a proof with weaker assumptions and more correct proof always constitute new scientific achievement. Taking into consideration the above statement it is not possible to regard Witelo's 'Perspective' as compilation of his predecessors' works given in a more comprehensive way. Besides, as the authors of the Polish translation write the development of optics owns Witelo its first geometrical formulation.

In the 17 [th] century Witelo's work was out of use due to fast development of physical science, including optics, and appearance of many modern publications connected with this topic.

Using a term perspective in this paper the author had in mind not only contemporary understanding of this notion but also the meaning which used to be associated with it in the

Middle Ages and ancient times. This term was used to describe everything that was associated with optics, sense of seeing and the way of picture creation in human eye.

The presented publications are not typical geometry textbooks since they do not present any method of projection, any construction used for drawing. They are rather analysis of the way of picture creation in human eye and compilation of observation results of the way of light ray. The way of understanding a term perspective at that time was different from contemporary one. Witelo explains it in a very complicated way when he writes in his introduction to 'Perspective' [3]: 'Bearing in mind that the same power of form goes into matter and senses, and that light is the first form perceived by senses and that I am going to study carefully causes of all being received by senses which in great variety are presented by our sight  I have decided to (…) deal with studying visible beings, as many scientists who worked on them before me on this field of science calling it perspective. The term used by them I fully praise and accept…'

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WITELO I ALHAZEN NAJWYBITNIEJSI PERSPEKTYWIŚCI ŚREDNIOWIECZA

Artykuł stanowi próbę przybliżenia postaci średniowiecznych optyków Witelona i Alhazena oraz podkreślenia wartości i znaczenia napisanych przez nich traktatów, dla późniejszego rozwoju perspektywy. Pozycje te były pierwszymi, w których, po wielowiekowej przerwie trwającej przez całe niemal średniowiecze, zajęto się problemem perspektywy i które dały początek nowej fali zainteresowania tym tematem. Stanowią one nie tylko kompendium całej starożytnej wiedzy na temat optyki, ale rzucają nowe światło na sposób podejścia do procesu widzenia. Osoba polskiego uczonego nie jest obecnie dostatecznie znana i ceniona, mimo iż jego „Perspektywa" stanowiła najkompletniejszy wykład z optyki w średniowieczu i służyła do XVII wieku za podstawowe dzieło w tej dziedzinie.