A Brief History of Light

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Thinking about light, we immediately realize three directions of human's dealing with it: first, the observation of light, second, the myth of and praying to light and third, the usage and rationalization of light in physics and technology. All three directions of our modern world have roots in very old history and accompany mankind from their early beginnings and in every culture. The emotional connection humans feel with celestial games of light and darkness as well as warmth and coolness during seasons and lunar phases caused early and perpetuating observations and consequently, the knowledge of calendar signs. Since calendars have always been used for religious purpose to date public holiday and so on, making calendars and observing the celestial rhythms have been a special duty of priests and the gods have been located in or above the sky. To summarize, we can conclude that light influences all directions of our life. The question of this article is how long back in history we can pursue the traces of human relations to light.

Figure 1: Today's culture illuminates the night. Satellites mapping the Earth's surface at night show clearly in which areas of this planets humans live in.[1]

Our modern civilization is able to live in brightness all the time and whenever we want to have artificial light (see fig.1). In this century, probably every average human being knows how to switch on the light in a room at night by only clicking on a button. In school, we have learned that the button closes an electric circuit and due to the voltage potential, a stream of electrons travels through the cables and induces a glowing of the matter in the light bulb (gas or a cable or whatever). So we have the impression of understanding how it works. But the real understanding of modern physics is much more complex: consider the atoms in the light bulb. Among other things they contain electrons on different energy levels and we can imagine that an electron falling from an upper level to a lower one emits the difference in energy as a photon – a particle of light – with a certain frequency (i.e., a certain color). Furthermore, the frequency (color) depends on the difference of energy between the levels where the electron jumps. At an even closer look, we have to consider the electrons as waves and not as particles. Therefore, they have an intrinsic wave energy. Again, we have to develop another model to explain the nocturnal illumination of our planet by human activities using the wave energy instead of energy levels...

Finally, we think we know a lot about our technical and natural environment but in fact, there are so many things, which are undiscovered, and even the few things we already happen to know have been developed over huge periods of time with regard to the existence of mankind. The knowledge that the color of light emitted by a light bulb depends on the energy the electron bridges goes back only to the previous century. The physics was written in the famous formula $E = h \cdot f$ published by Einstein in 1905 (Nobel Prize 1921). The description of light as electromagnetic waves is only forty years older. James Clarke Maxwell published the mathematical description of it in 1862. The understanding of white light as a composition of all colors of light is a bit more than another century older, when Newton experimented with glass prisms in a dark room during the 17th century and later published his 'Opticks' in 1704.

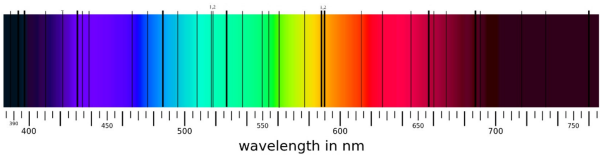

Figure 2: White light is a composition of all colors of light. In the 19th century, the physicist Wollaston and the optician and glas expert Fraunhofer independently discovered black lines in the artificial rainbow a prism makes from sunlight. Today we know that these are absorption lines indicating the chemical composition of the sun's atmosphere.[2]

Newton's experiments were the first steps toward an understanding of the physics of light. Before, there were only different considerations of geometrical optics; i.e., people considered bunches of light rays or beams of light like they are seen switching on a flashlight or an artificial lamp in the night. In foggy air, we can see light being emitted as a directed beam and so the idea of focussing the light of a fire rose up at least in antiquity. Of Archimedes, for instance, we know that he constructed instruments and military devices, sometimes using fire and light.

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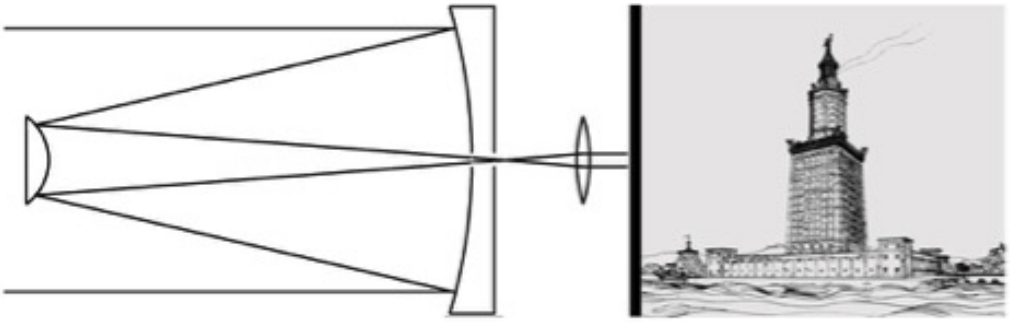

Figure 3: Since antiquity the technology of collecting and focussing light by concave mirrors has been known. The lighthouse of Alexandria was one example of an artificially directed beam of light.[3]

We also know that the olympic fire was kindled in the focus of a concave mirror and that also concave mirrors bunched up the light in light houses at least since hellenistic times: the lighthouse of Alexandria (3rd century BCE) was one of the seven wonders of the ancient world because of its enormous height. The history of using light for a technical purpose is, therefore, at least a few dozen centuries old.

Nevertheless, we know that people even before hellenistic times tried to invent myths to 'explain' how the light came into the world. Famous are the Bible's verses describing that God made a small light and a big light and divided the darkness from the bright daylight. Also well known is the Greek hero Prometheus who stole the fire from the gods and brought it to Earth for human usage. All these kinds of stories reflect the human consciousness of the importance of light for life on Earth. Not every culture projects the importance in the celestial body of the Sun (like the Egyptians did), but in some cases it is the fire or the light itself: notice for instance that in the Bible, God created the day-night pair way before he created the disks of Sun and Moon in the sky: 'And God said, "Let there be light", and there was light. God saw that the light was good, and he separated the light from the darkness. God called the light "day", and the darkness he called "night".' is the very first creation in sentence 3-5 to create the very first day. Sun, moon, and the stars appear only in sentence 14-16; they are created only on the fourth day to govern day and night and to make signs for his people. This means that also in the Jewish culture – inspired during the Babylonian exile, where chapter "*genesis*" of the Talmud and later of the Bible had probably been transferred to this form – the concept of light has been considered independently from the celestial bodies: it is not the sun which makes the day, but the daylight is naturally there, accompanying the solar disk in the sky. With regard to nature, this is not surprising since light in the sky is not only at the place of the sun's or moon's disk, but the whole hemisphere is illuminated.
Additionally, light in general can be generated not only by the sun but also by an oil lamp or by an open fire. That is why, even in mythological thinking it is easy to consider light as one entity and the disks of the sun and the moon as another two entities like 'clusters of light' or illuminated celestial disks – in fact the Bible does not explain the concept behind them.

Nevertheless, astronomical observations of the 'lights in the sky' are documented since ancient times. We know about continuous observations of the stars from historical sources in ancient Greece, ancient China and ancient Babylonia – probably also practiced in other cultures which did not conserve written protocols. The Babylonians' believe in gods communicating with humans by giving signs on earth and in the sky led to the wish of systematic observations: If the gods expressed their intents by signs, predicting the signs led to a better understanding of the intentions and wishes of the gods. Therefore, earth and sky were observed in order to conclude, which signs appeared together and which were followed by each other. During the first millennium BCE, there was a huge project of writing scientific diaries of all those observations, regularly noting the water level of the Euphrates river as well as positions of celestial lights and prices of common trading goods. This awakening of systematic observation and deriving patterns (rhythms, dependencies, cause-effect-pairs etc.) is the root of all sciences: it is one of the crucial conditions that the light of science can shine into our culture; i.e. that causal connections can be discovered and falsified between observed phenomena, world views rise and fall, and technologies can be developed to improve our daily life.

As far as we know, Babylonian astronomers observed the path of the moon by occultations of stars and wrote it down canonically at least in the later half of the second millennium BCE. Since they also found out that the path of the sun was roughly similar but inclined, they also observed helical risings and settings of the small lights (stars) of the morning sky to indirectly determine the path of the sun among the stars. The result of those observations was the zodiacal circle, which was divided into twelve equidistant zodiacal signs in the later half of the first millennium BCE. This equally divided circle was taken over by Greek astronomers to make first coordinate systems: one of the basic concepts of modern mathematics. Therefore, the observation of the lights in the sky and the wish to predict their appearances caused a new light on abstract thinking.

Figure 4: A reconstruction of the circular enclosure near Goseck, Germany. Researchers think that the gates in the palisade circles mark the directions of the solstices for an observer at the center.[4]

However, we assume that the observations of sun and moon date back to many millennia earlier. The enormous significance of the sun in Egyptian culture is preserved in religious texts and funeral rituals since the third millennium BCE and from the same era observations and predictions of the celestial light-and-shadow games are known in China. Famous is the story of the two Chinese astronomers, He and Xi who were beheaded because they failed to predict the solar eclipse in 2137 BCE. Additionally, there are some hints that even the circular enclosures in central Europe from neolithic times (ca. 4500 BCE) have had some use for observing the turning points of the sun; i.e., the solstices, where the duration of daylight begins to increase (winter) or decrease (summer).
Even today, we celebrate the two points of the shortest and the longest night of the year – interestingly in both cases with fire. The midsummer night is celebrated with big open fires in the countryside, where people meet and sit together. Around winter solstice, the Christian and Jewish cultures celebrate "festivals of light", i.e. Hanukkah in the middle of December (25. Kislew) and Christmas, the birth of the "light of the world" on December 25th. To conclude, we can say that – since many millennia – humans observe light, adore light, pray to light. We analyze light, try to describe the rhythms and nature of light, try to understand light and for roughly one hundred years, we make models of light, compare it with rays, waves, particles and so on. But what is light? To be honest we do not know exactly.

References

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[2] http://sites.msudenver.edu/sessionl/ (last access on 02.01.2016).
[3] Drawing Prof. Hirsch, 1909.
[4] Drawing Rainer Zenz, based on plans from the Institute for Prehistoric Archaeology, Martin-Luther-Universität Halle-Wittenberg.