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ARCHAEOASTRONOMY AND EXAMPLES OF RESEARCH IN SERBIA

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Abstract. In this contribution, the significance, development and importance of archaeoastronomy will be discussed, some examples of research and objects of importance for this topic will be presented and the history and development of archaeoastronomy in Serbia will be briefly reviewed.

1. ARCHAEOASTRONOMY AND ASTRONOMY IN CULTURE

Archaeoastronomy is an interdisciplinary science that investigates and considers how in the past humans observed sky and celestial bodies, understood and recorded what they saw on it and what it meant in their culture, religion, and worldviews. Aveni(1988) defines it as "the study of the practice and use of astronomy among the ancient world cultures based on all accessible forms of evidence, written and unwritten." Ruggles (1991) considers that the word "old" can be freely omitted, from Aveni's definition, to include ethnoastronomy.

The term archaeoastronomy itself was first used by Elizabeth Chesley Baity in 1973 (Sinclair, 2006), although many previous studies may be considered as archaeoastronomic depending on the definition.

Close relations exist between Archaeoastronomy and ethnoastronomy, anthropological studies the sky observations in both earlier and present societies, as well as the history of astronomy, which uses available records to consider the development of astronomy, understanding of the universe and its phenomena and astronomical practice throughout history. It is a relatively new science, developed as a result of exploring the possible astronomical significance of the directions that connect an object, a marker on the horizon and some astronomical phenomenon (sunrise or sunset on solstice, star or constellation rising or setting...). Largely contributed to its developpment and the study of astronomical aspects of the Stonehenge Megalithic Monument in England and astronomical alignments in the architecture of the ancient inhabitants of South America (Aveni, 1986; Urton, 1981, 1990).

Archaeoastronomy uses a number of different methods that include archaeological, anthropological, astronomical, statistical, probabilistic and historical (Iwaniszewski, 2003) and we would add and geodetic ones. It has particularly developed over the last fifty years.

The first international conference that brought together researchers from around the world was held in Oxford in 1981. These were the very beginnings, when, first of all, it was necessary to work on defining and elaborating the research methodology and formulating the terminology of new science. On it, archaeoastronomers from Europe advocated a methodology based on artifacts, facts and statistics. For example, if most of the graves are oriented in one way, or on a possible landmark on the horizon, the sun, moon, individual stars or constellations rise or set on a day associated with an astronomical phenomenon (summer or winter solstice, some holiday ....) it is concluded that such an event had a significant place in the culture, settlement or temple under consideration. American scholars, in view of the much more modest archaeological findings related to Native American tribes, rely much more on the writings of the colonists and ethnographic methods (Zeilik, 1985, 1986), trying to understand the role of astronomy in American civilization, how activities related to heaven and celestial phenomena and bodies looked like, and what it meant for the community under consideration. This enabled them to identify motives and analyze them, which in Europe is generally just a guess. The differences in methodology and topics for research were so great between European and American archaeoastronomers that the Conference Proceedings were printed as two separate volumes (Aveni, 1982; Heggie, 1982). Even today, according to the color of their covers, one speaks colloquially of "green" and "brown" archaeoastronomy. These meetings, with the name Oxford Conference, are still held every four to five years.

Not only did archaeoastronomers disagree on methodology, but discussions were also held on the name of this new scientific discipline. Three major international societies associate archaeoastronomy with cultural research (ISAAC - International Society for Archaeoastronomy and Astronomy in Culture, founded in 1995, which is behind the Oxford Conferences and the journal: *Archaeoastronomy - the Journal of Astronomy in Culture*; SEAC - La Société Européenne pour l'Astronomie dans la Culture, created in 1992, organizes a conference every year and publishes a peer reviewed Proceedings with presented contributions, and, since 2003, SIAC - La Sociedad Interamericana de Astronomía en la Cultura); Ruggles and Saunders (1993) propose the name *Cultural Astronomy*, and, there were and opinion, since it is often a matter of cosmological views, that the more appropriate name is *Cosmovision* (Aveni, 1986b).

For the first time *Cultural Astronomy* as a course on the university has been introduced in 1990 at the University of Leicester by Clives Ruggles, an astronomer and archaeologist, who, after his retirement, became President of the UNESCO Commission on the Protection of Cultural Monuments of Significance for Archaeoastronomy. It was an optional course in the third year of archeology studies, and in 1991 the Chair for Cultural Astronomy was established.

At the Faculty of Mathematics in Belgrade, on Department of Astronomy, from 2009 to the 2014/2015. school year, there was an optional course of *Archaeoastronomy* in doctoral studies, but in the PhD program for 2015/2016. year and later this does not exist. Meanwhile, only Jovan Aleksić passed the exam, and the examiner was author of this paper.

2. SOURCES AND INVESTIGATIONS

The basic sources that provide us with information about how humans interacted with the sky and celestial phenomena are *the significant directions and orientations*

of particular constructions, objects, ethnographic research, calendars, written sources, myths and *cosmologies*.

Significant directions. Basic methods for investigation of significant directions were developed by Alexander Thom during an extensive examination of megalithic monuments and sites in England and such studies are characteristic for "green" archaeoastronomy. He considered that by looking at the horizon and what can be seen on it, one could determine the specific day of an astronomical phenomenon in the year. One has to find a place to see where the Sun is rising or setting on the day of an astronomical phenomenon, such as the summer or winter solstice. To confirm this assumption, he considered a large number of megalithic monuments. Any such individual direction might be a coincidence, but if we have a number of them, it shows that at least one part is intentionally oriented (Thom, 1967).

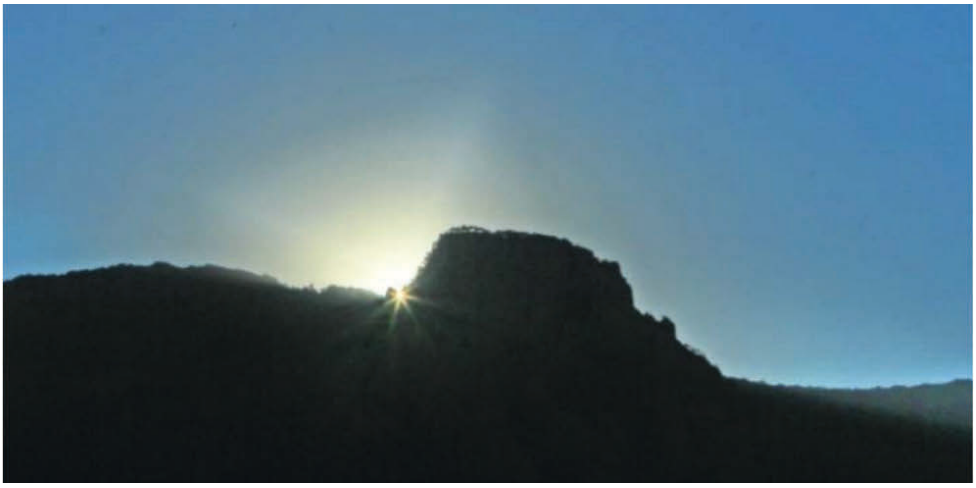

Figure 1: The first sunrise on the mountain Treskavac on the horizon of Lepenski Vir, 21^{st} of June 2017 (photo Stanko Kostić from the position 44,557142 N 22,026590 E - photo from Bajić and Pavlović (2019)

Particularly impressive is the case when a mountain on the horizon, in a certain day, blocks temporarily the solar disk on its path, so that it appears as if it is rising or setting twice. If the event is seen on the day of an astronomical event, such as the summer or winter solstice, from the place where is the object of importance to the local community, it is a convincing assumption that it was observed for the purpose of determining the date of an important holiday or for setting the calendar.

One of such places is the Mesolithic settlement of the Lepenski Vir and the volcanic rock Treskavac on the Romanian side of the Danube. Their astronomical and calerndrical aspects attracted attention of Živojin Andrejić (2002, 2004a, 2005) who from 1999 to 2005, observed and photographed rising and setting of Sun and Moon on Treskavac and how this could be used for calendrical purposes (Andrejić, 2005). An important study on Lepenski Vir including astronomical aspects is published also by Ljubinka Babović (2006). In 2014, Aleksandra Bajić and Hristivoje Pavlović found that the phenomenon of double sunrise on the Treskavac could be seen from the Lep-

Figure 2: Entrance to Newgrange. Above you can see opening for the entrance of solar rays (https://edition.cnn.com/travel/article/newgrange-ireland-stone-age/index.html)

enski Vir settlement only on the summer solstice. Namely, the Sun first appears in a relatively narrow gap, which lies between the northern slope of the Treskavac and a small solitary pointed rock on it (see Fig. 1). Then it follows Treskavac and rises again on its flattened top. Given the width of this very narrow gap on the horizon, Bajić and Pavlović found (Bajić and Pavlović, 2015, 2018, 2019), taking into account changes in the inclination of the Earth's axis and precession, that this unusual phenomenon can be seen from a specific place in the former position (which is today under the water), uniquely on the summer solstice which makes it possible to determine that day of the year, which is the basis for the solar calendar.

Such special directions to markers on the horizon, which, based on some astronomical phenomenon, helped to determine one special day of the year, were very useful for orienting in time and making calendars. If there was no suitable marker, a special opening could be made in the building, which, for example, allows that the Sun illuminates a certain place once a year. The most famous such object is Newgrange in Ireland, which dates from 3300 to 2900 BC. (Eogan, 1991). Around the winter solstice, the solar rays for several days enter the interior of the building through an opening above the door and, on the day of solstice, fall on the altar. In front of the door is a large stone (see Fig. 2), as if to emphasize that it is not the entrance for the men, but for the Sun God, who should not be disturbed. In Serbia Andreić investigated the illumination by the Sun of specific frescoes in a particular day in the St. Trinity Church in Resava (2011), monasteries Studenica, Žiča and Manasija (2012) and the white church in Karan (2013).

Several astronomically significant directions related to the Sun and the Moon were also determined in England for the Megalithic Monument Stonehenge, built and

rebuilt from 3100 to 1600 BCE. The famous astronomer Fred Hoyle explained how Stonehenge could serve for the prediction of solar and lunar eclipses and determination of solstices, analyzing the resulting cultural implications (Hoyle, 1977).

In Serbia, Andrejić (2009) discussed astronomical directions and orientations in Naisus in addition to Lepenski Vir, Aleksandra Bajić performed an archaeoastronomical analysis of Bogovo Gumno (Bajić, 2012) and the Stone Age Shrine of Pojate-Pojilo near the village of Belica (Bajić, 2016). Moreover, the astronomically significant directions in the palace of the Roman Emperor Galerius, Romuliana Felix in Gamzigrad, have been investigated (Andrejić, 2004b, 2019; Bajić and Dimitrijević, 2019) and the examinations of the archeological site of Sharkamen from the Roman period (Andrejić, 2019) were also carried out. Andor Vince and his associates investigated the orientations of graves and skeletons (Vince et al., 1996; Vince, 1998), what Borislav Jovanović also briefly considered in an overview of some archaeoastronomical examples in the archaeology of the central Balkans (Jovanović, 2007). Živojin Andrejić investigated the orientation of the temples (Andrejić, 2016), and Milutin Tadić, assuming that some proto-masters simply looked where the sun was rising on the day they began construction and took it as east, not only determined the orientation, but also tried to determine time of the beginning of the construction of certain medieval churches in the autonomous region of Kosovo and Metohija (Tadić, 2014).

Objects. Among the most interesting objects of archaeoastronomical significance are the Nebra sky disk from Nebra in Germany, dating from 1600 BC, which is the oldest known pictorial representation of the cosmos. In 2013, it was listed on the UNESCO's Memory of the World and declared for one of the most important archaeological discoveries of the XX century. Of particular importance is also the Antikythera mechanism, an ancient Greek analogous computer with about thirty gears, which was used for astronomical calculations of positions, eclipses and calendar. At the Arts et Métiers Museum in Paris, I saw an entire room dedicated to this marvel of the ancient world. Archaeoastronomical significance have and objects from prehistoric times, with 12 notches indicating the solar cycle or 28 for the lunar one. As an example of such research in Serbia can be cited the book of Milorad Stojić on the archaeological site near the village of Belica (Stojić, 2018). Such items include as well coins with astronomical content (Dimitrijević, 2007).

Some ethnographic studies of interest in the study of astronomy in culture in Serbia are in references Božić (2005) and Vuca (2007).

A common reason for the usefulness of astronomy and the need for it was in earlier times, first and foremost, to develop a sufficiently precise **calendar** for agricultural purposes. In Serbia, this issue, together with time measurement, is considered in Jovanović (2005, 2009), and Babović (2001, 2016, 2018).

Finally, in our country, a larger number of papers (Janković, 1954, 1989; Dimitrijević, 1998; Danezis et al., 2007; Theodossiou etal., 2011abc; [37-42] deal with considerations related to archeoastronomy and astronomy in culture, based on **written sources, myths and cosmology**, what is one of the main forms of "brown" archaeoastronomy

3. BEGINNINGS IN SERBIA

Although particular works that could be classified in this field, existed earlier, the first conference dedicated entirely to the history of astronomy, with a number of contributions that could be included in archaeoastronomy, was the VII National Conference of Astronomers of Yugoslavia, held in 1984, on the 50^{th} anniversary of the founding of the Astronomical Society "Rudjer Bošković". The next was the session "Astronomy in Archaeology, History and Culture", dedicated to archaeoastronomy, organized for the first time on the 4^{th} Yugoslav-Romanian Astronomical Conference in Belgrade (May 5-8, 1998). The study about the astronomical orientations of graves and skeletons in Gomolava and Mokrin, presented at the XI National Conference of Astronomers of Yugoslavia 1996 in Belgrade, by A. Vince, B. Jovanović, I. Vince and O. Vince, was the first archaeoastronomical investigation in Serbia, by a joint team of archaeologists and astronomers. That year, at a meeting held on June 12^{th}, astronomers (M. S. Dimitrijević and Ištvan Vince) and archaeologists (Borislav Jovanović, Milorad Stojić, Andor Vince and Živko Mikić) formed a Group for archaeoastronomy that had been active for about a year. Živojin Andrejić observed and photographed from 1999 to 2005, from Lepenski Vir, rising and setting of Sun and Moon on Treskavac and discussed how this could be used for determination of particular dates (Andrejić, 2005). In 2009, at the Faculty of Mathematics in Belgrade, at the Department of Astronomy, the course of Archaeoastronomy was introduced as an optional course in doctoral studies, which existed until 2014/2015. The archaeoastronomical measurements and observations of the double sunrise with the study how this could be used to determine the beginning of the seasons and to correct the calendar, started by Aleksandra Bajić and Hristivoje Pavlović, in 2014, at Lepenski Vir. That year, the Society for Archaeoastronomical and Ethnoastronomical Research "Vlašići" (http://www.vlasici.org.rs/) was founded in Belgrade.

Archaeoastronomy in Serbia has achieved a number of original and interesting results, but it is not developed like in some of the surrounding countries, such as Greece and Bulgaria in particular.

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