Mediterranean Archaeology and Archaeometry, Vol. 16, No 4,(2016), pp. 329-334

10.5281/zenodo.220954

SKY SIMULATIONS FOR THE PALAEOLITHIC EPOCH

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Received: 10/02/2016
Accepted: 21/03/2016
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ABSTRACT

The simulations of the sky for the very far past are briefly discussed, and a possible application to the study of the Bear constellations, in particular for the epoch of the last glacial maximum, is presented; reference is made to the different length of seasons, climate and environment. Many ethnographic studies described the special relationship between men and bears, in connection also with a cosmic hunt, and it may be possible that such a relation dates back to the Palaeolithic epoch.

KEYWORDS: astronomical software, Ursa Major, palaeoclimate, ethnography.

1. INTRODUCTION

At past SEAC meetings some contributors discussed the position of the stars in the sky tens of thousands of years ago, using the available software for representing the constellations of past epochs. However, usually such software should not be used to simulate the sky of the very far past, since the results are unreliable for a time interval longer than some thousand years. This is due to the polynomial expressions in time adopted for computing the precession effect; their validity is generally limited to few thousand years. As regards our own published works, we made just a comparison of the shapes of the constellations taking into account only the proper motion and radial velocity effects, in order to avoid that difficulty (e.g. Antonello, 2009).

There are available programs based on the numerical integration of the equations of dynamics, and so it is possible to overcome the problem of the polynomial expansions. In the present work, however, we have tried to assess the issue by adopting a simpler approach, by using the trigonometric formulas developed by Berger (1976, 1978), whose validity is of the order of some million years; those formulas were intended mainly for application to the study of palaeoclimate. In any case, even adopting other approaches, it seems not reasonable to expect a precision better than some arcminutes. That is sufficient for a qualitative discussion of the stars and constellations seen by our ancestors during the Palaeolithic, and, given the anthropological importance of the bears, we will show some examples in relation to Ursa Major.

2. DYNAMICS

The parameters of the orbit of the Earth (ecliptic) change with time. They are the eccentricity, the obliquity (i.e. the inclination of the Earth rotation axis with respect to the axis of the orbit), the intersection between the ecliptic and the equatorial plane (precession effect), the longitude of the perihelion, and the position of the ecliptic (inclination and longitude of the nodes) with respect to the solar system reference plane. Berger (1976) obtained trigonometric expressions for the various parameters, with amplitudes, frequencies and phase terms, and adopted the epoch 1850.0. We used such expressions, and we made a check of the results with those collected and published by that author referred to 1950.0. A comparison of the obliquity and general precession with those obtained with an accurate expansion in time (Laskar, 1986), for a time interval of 10,000 years, shows that the accuracy is of some arcminutes, and we can estimate that the corresponding uncertainty in time of a given position (coordinates) of a star in the sky is of several centuries.

Recently, we were informed about the paper by Vondrák et al. (2011), where new expressions containing both trigonometric functions and polynomial terms were used. The accuracy of their orbital solution is better than few tenths of a degree (i.e. some tens of arcminutes) below 200,000 years. A preliminary comparison shows that the difference with our results is of the order of just few arcminutes in the case of the obliquity, while it increases with time in case of the precession (several tens of arcminutes above 50,000 years). The main reason of the increasing difference for the precession appears to be related to a correcting quadratic term in time (Vondrák et al. 2011; p. 2).

One should not forget that the evaluation of the accuracy of the results of the computations requires a comparison with real observations, and that means only recent epochs when precise data are available. Therefore, the true validity of the results very far in time cannot be in principle assessed for any model of the Earth dynamics, although geological data could probably supply an indirect check (e.g. Laskar et al., 2011).

It may be worth to recall that, because of the change of obliquity, the true displacement of the mean north celestial pole during a precession cycle with respect to the 'fixed' stars is not a closed circle; therefore, the figures illustrating the precession effect usually found on the web and in books could be misleading. Moreover, given the accuracy of several arcminutes, it is not worth to try to get 'better' results by including the nutation, since the amplitude of such an oscillation is just about 9 arcseconds.

It could be worthy to recall also the estimate of the length of a precession cycle. Since it does not repeat exactly, it is not possible to recover the same reference point in the sky after each cycle. One can estimate only a periodicity, which will depend of course on the selected epoch and reference point. For example, if we adopt the values of 0, -2π and 2π of the general precession and the epoch 1850.0, we get a periodicity of about 25,100 years for the previous cycle, and about 26,400 years for the current one.

3. RESULTS AND DISCUSSION

3.1. *Homo sapiens and the Palaeolithic sky*

Before showing some examples of sky simulations of the Palaeolithic epoch, let us recall the scenario of the evolution of *Homo sapiens* generally assumed by anthropologists, taking into account the results of genetic studies, summarized for example by Gibbons (2011). The chief ancestors of modern humans arose in Africa, about 200,000 years ago. Our ancestors interbred with Neanderthals, probably in the Middle East or Arabia, in the past 100,000 years (thus Neanderthals left their mark in the genome of living Asians and Europeans). Later, a subset of the group of modern humans who carried some Neanderthal DNA headed east toward Melanesia and interbred with Denisovans in Asia. As a result, Melanesians inherited DNA from both Neanderthals and Denisovans (Gibbons, 2011). *Homo sapiens* got out of Africa several times (e.g. Dennell, 2015), but it seems that the substantial dispersal occurred about 50,000 years ago, and the presence in Europe is between 45,000 and 40,000 years ago. For example, recent genetic data suggest the presence of a modern human in western Siberia about 45,000 years ago (Fu et al., 2014). His genomic segments of Neanderthal ancestry appear substantially longer than those observed in present-day Eurasian individuals, indicating that Neanderthal gene flow into the ancestor of that modern human occurred 7,000-13,000 years before he lived (Fu et al., 2014). Other interesting examples of genetic analysis are discussed by Seguin-Orlando et al. (2014) and Fu et al. (2015).

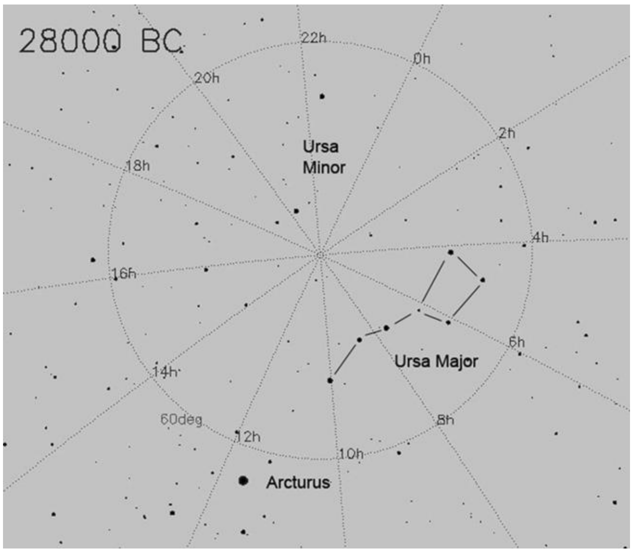

Figure 1. Ursa Major and Ursa Minor in the year 28,000 BC. The north celestial pole was located between the two constellations.

In our previous work (Antonello, 2009) we have discussed the constellation Ursa Major as seen around 54,000 BC., and we showed how one could possibly interpret it as a bear. The bright star Arcturus was closer to Ursa Major than today, while Ursa Minor was very different from today. One could wonder about the possible cultural contribution by Neanderthals to the identification of Ursa Major with a bear. Generally speaking, according to Hublin (2015) some questions have arisen in the field of prehistory regarding possible cultural interactions between Neanderthals and the immigrant *Homo sapiens* in Europe. Although there is no evidence for prolonged local coexistence of Neanderthals and modern humans in any region of Europe, the ages of the latest directly dated Neanderthal sites (about 41,000 years ago) suggest that the chronological overlap between the two groups might have been quite long on continental scale (Hublin, 2015).

On 28,000 BC the two Bears had the shape and the position shown in Figure 1; the north celestial pole was located between the two constellations. The oldest drawings in the Chauvet cave (France), which include also the representation of a *ursus spaeleus* (cave bear), have been dated around 32,000 years ago (Feruglio, Baffier, 2005), although there are some discussions about the reliability of the dating (e.g. Combier, Jouve, 2014).

At the end of the coolest phase of the last glacial maximum, at a latitude of 45 deg, Ursa Major was visible during the night looking toward East (Figure 2), South (Figure 3) or West (Figure 4). Ursa Minor was circumpolar and did not set, while Ursa Major was setting, with her three cubs, or three hunters, chased by Arcturus (Figure 4). At that epoch the north celestial pole was located between Cygnus and Cepheus constellation. This was the probable epoch of the settlement at Lascaux cave (France), since it has been estimated between 17,180 and 18,600 BP (Aujoulat et al., 1998).

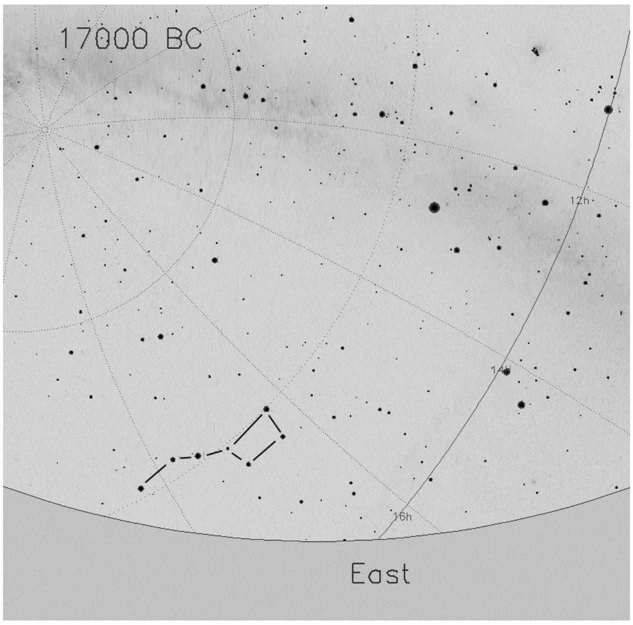

Figure 2. The rising of Ursa Major in 17,000 BC, seen at the latitude of 45 deg. Ursa Minor is located above Ursa Major. On the right, one can see Auriga and Gemini. The continuous line with the right ascension coordinates is the celestial equator. The north celestial pole was located between Cygnus and Cepheus constellation.

We note that the position in the sky of Ursa Major on 17,000 BC, with declination between 20 and 30 deg and right ascension about 17 hours, today is occupied by the lower half of Hercules constellation. Hence, it is interesting to note that Ursa Major was mainly visible from spring to autumn, and less visible during winter. Assuming the constellation was already identified as a bear during the Palaeolithic, as suggested by several authors such as Gingerich (1984) and Gurshtein (1993), the visibility could be put in relation with the true life of a bear, that was presumably hibernating during winter.

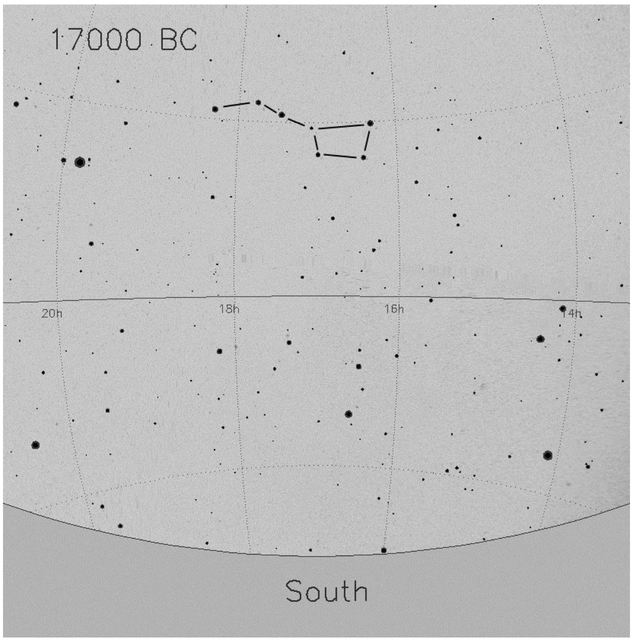

Figure 3. The culmination of Ursa Major; its altitude is about 70 deg. The bright star on the left is Arcturus. Note the Leo constellation located just below the equator.

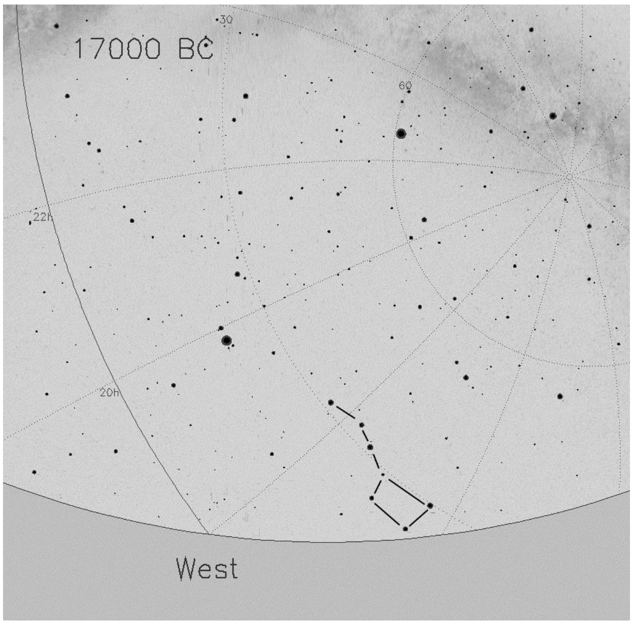

Figure 4. The setting of Ursa Major.

3.2. *Seasons and environment*

When considering the Palaeolithic epoch, however, one should take into account also the different length of the seasons, the different climate and the different environment.

1. The length of the astronomical seasons depends on the ellipticity of the orbit; for example, a larger eccentricity means a larger difference of the lengths. The seasons 'rotate' on the ecliptic plane and the combination with the astronomical precession gives a period of about 19,000 – 23,000 years, or climatic precession (Figure 5; Berger, Loutre, 1994).
2. During the Palaeolithic epoch, for several tens of thousands of years, the mean temperature was lower than today; all the available data confirm that this was, at different levels, a global climatic trend (see e.g. some references in our previous work; Antonello, 2013). In Europe, the temperature anomaly, that is, the difference from the present average temperature, was probably larger during winter (Davis et al., 2003); in other words, the temperature was probably extremely low during that season.
3. Some researchers have reconstructed the possible climate and environment during the Palaeolithic epoch on the basis of the pollen distribution. During the last glacial maximum, the biome (ecosystems) distribution differed fundamentally from the present pattern: the landscape was mainly covered by a cool steppe vegetation, although there is some evidence for forest stands in Mediterranean regions and tundra shrubs in France (Peyron et al., 1998).

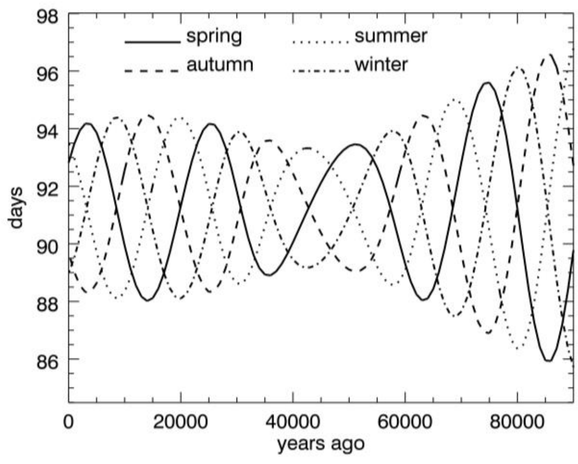

Figure 5. Length of the seasons in the past 90,000 years.

After the end of the last glacial maximum the landscape changed completely. The mean temperature increased, the polar desert and ice extent decreased and there were progressively larger woods and forests. Then the cold climate came back again (the so-called Younger Dryas period) from about 12,900 to 11,700 years ago (Carlson, 2013). After that period, the climate got warmer and stabilized (Holocene Climatic Optimum), and then a progressive aridity begun at low latitudes (e.g. Brooks, 2006).

3.3. *Men and bears*

As a final note let us recall that an extensive ethnographic literature exists on the unusual characteristics of the relationship of the men with the bear, on the bear ceremonialism, and more generally on myths regarding a cosmic animal and a cosmic hunt in relation to Ursa Major (e.g. Frank, 2015).

The bear was considered an ancestor, or a distant relative, with a superior intelligence, and smarter than his 'descendant', the man. As summarized by Germonpré & Hämäläinen (2007), people have felt a kind of kinship with bears since humans and bears share many characteristics. They live in the same regions and eat the same fish, roots, and berries. Unlike other animals, bears can stand on their hind legs as humans do and they can use their fore paws as humans use their hands. A bear's skinned body looks human, and several bear bones resemble human bones, which lends credence to the view that the animal is really a man in disguise, while transformations between humans and bears can be found in many tales of North America tribes. In Eurasia, people believed that the bear was the only animal that has a human-like soul.

4. CONCLUSION

In the present note we have briefly discussed the situation of the available software for the simulations of the sky of the very far past. We have shown a possible application to the study of the Bear constellations, in particular for the epoch of the last glacial maximum. It may be possible that the special relation between men and bears described in many ethnographic studies dates back to the Palaeolithic epoch.

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