PLANETARY SCIENCE EDUCATION BY FOCUSING ON SPHERICAL ASTRONOMY: THE ROLE OF THE ECLIPTIC IN THE 26000 YEARS OF PRECESSION CYCLE: COMPARISON OF RECENT AND ARCHAEOLOGICAL DATASETS. ***Záhonyi A.[1], Ságodi I.[2], Bérczi Sz.[3]*** *[1]Cosmic Materials Space Research Group, H-1117 Budapest, Pázmány P. s. 1/a. Hungary, (azahonyi@freemail.hu), [2]Szekszárdi Garay János High School, H-7100 Szekszárd, Szent István tér 7-9. Hungary, (sagodi62@freemail.hu), [3]Eötvös University, Faculty of Science, Dept. of Materials Physics, Cosmic Materials Space Res. Group, H-1117 Budapest, Pázmány P. s. 1/a. Hungary, (bercziszani@caesar.elte.hu)*

Introduction: Spherical astronomy today, in the world of interplanetary travels, is the basis of spatial orientation in space and on the surface of the Earth or other planets. It can be exciting to teach your students when coordinate systems are learned through puzzles. Here we show an example: of the ecliptic coordinate system. The attached puzzle is an ancient disc from Tatárlaka (Tărtăria, Transylvania, Roumania) [1].

Spherical astronomy: Measured by decades, centuries of time, constellations are a kind of constancies and, along with other constants, a rather solid orientation directions for the sky. The coordinates to give their position, the fixed basic coordinates relate to the pole and celestial equator. Another fixed „belt" is the celestial route of the Sun, the ecliptic. These constraints only change a little, or move in the sky only on a centuries-old scale.

How the precession transforms the dominant constancies: the role of ecliptic: However, if you switch to a 10,000-year scale, the role of the constancies of the sky will change. Movements in the precession of the Earth's axis of rotation are at the forefront: the ascending node (vernal equinox) of the ecliptic is in recession on the celestial equator, and so does the circling shift of the celestial pole around the ecliptic pole in the Dragon constellation. On a 10,000-year scale, the most important constancy of the sky is the ecliptic (and the corresponding belt of zodiac constellations). Changes in the position of the sky - on a scale of 10,000 years - can be described by changes in the celestial equator relative to the ecliptic. (and correspondingly, by the celestial pole around the pole of the ecliptic.) Introducing and teaching this system is a nice space science education task. We do this task with the help of an archeological discovery, the disc (and tablet) of Tatárlaka.

The disc and tablet from Tatárlaka-Tărtăria

The Tartaria tablets has been discovered by Nicolae Vlassa Roumanian archaeologist (Cluj Museum) and his group in 1961. The tablets were formed from the local clay of the Maros river. However, two of them exhibited Sumerian jewelery ideograms (signs). (Fig. 1.) The arrangement of the ideograms on the disc showed a cross-like division of the circle (by two lines) to four parts resembling to an astronomical representation of the sky. Suggestion of astronomical representation had been given by Lazarovici, Merlini [2].

Fig. 1. The Tatárlaka (Tartaria) archaeological finds in Cluj Museum.

For teachers let it be a puzzle. Then: what age is recorded on this sky representation. It turned out from the solution of the ideograms, that most of them correspond to constellation names [3,4]. The disc and the "inscription" rectangular table also have a double interpretation: astronomy and a story of writing. The two are in close contact with each other, indicating the undivided nature of ancient culture. The disc can be considered disc as a "half of the sky" (Auriga-Sagittarius), a rectangular table with signs showing the "other half" of the cylindrical sky. The points of connection of the two star map sections are indicated by "V" signs. One such point is the Gemini (in the vicinity of Auriga and Orion), the other is the Sagittarius and its surroundings (Andromeda, Pegasus and Aquila, Ophiucus). The aforementioned constellations form the stations of the Zodiac and their immediate surroundings. There is a high probability that an ancient cosmic world model will stand before us. To solve the puzzle we reconstruct the position of the sky in the earlier ages.

The position of the sky today and once (10 000 years time scale): The movement of the sky can be illustrated by observing at a prominent time. Let's look at the starry sky on March 21st, at the time of the spring equinox, two hours before sunrise (This day was the beginning of the year in antiquity). The 26,000 years of the precession year divided into four parts, 6500 years to a quarter turn. After this time, the ascending knot retreated c.a. 90 degrees and the celestial pole was moved from the Ursa Minor to the vicinity of Bootes and Hercules.

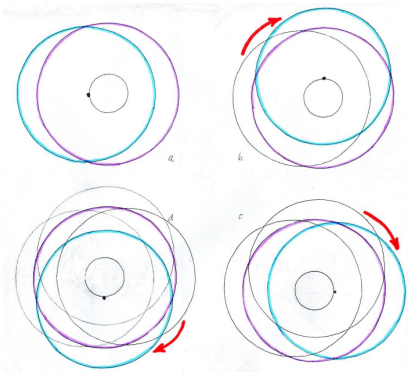

Fig. 2. Changes of the celestial equator (blue) position as compared with zodiac (violet). During 26 000 years 4 positions are shown. a) is the recent one, b) is the one ca. 6500 years ago, c) is the one ca. 13 000 years ago, d) is the one ca. 19 500 years ago. Point on the inner circle shows the actual pole of the (blue) equator at that precession state.

In 10-20,000 years, the shape of the constellations (seen from the Earth) is almost unchanged (although it is made up of stars at a great distance and with different brightness), so today we can observe the same shapes in the star sky as 5-7000 years ago. It is only at the beginning of the year that the constellation of the post-sunset (or sunrise) momentum differs - the reason for this is the "delay" due to precession.

Comparison of the quadrangle-after-quadrangle structure of the disc and that of the stages reconstructed by the moving celestial equator, we can formulate a suggestion. The disc of Tartaria represents a sky-arrangement when the Hydra constellation covered almost one third of the equator of that time (Fig. 3.). We reconstructed the relative positions of the celestial equator and the ecliptic in the 26 000 years cycle. Ca. one fourth of this cycle lasted since the time, when Hydra was the important constellation of the corresponding time, when the disc was recorded.

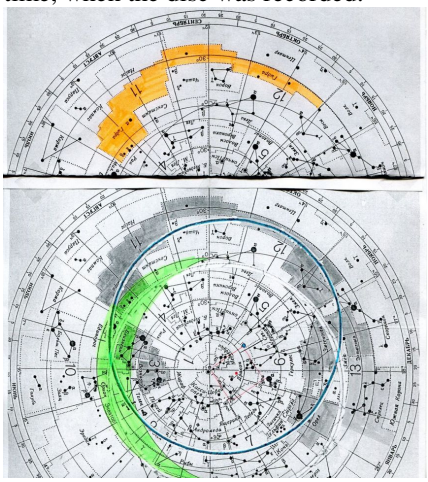

Fig. 3. Top image. The yellow region shows the portion of the Hydra constellation in the sky. Lower image shows the approximately sketched equator (and pole, all in blue) 6500 years ago. Then the equator had run one third arc in the Hydra region.

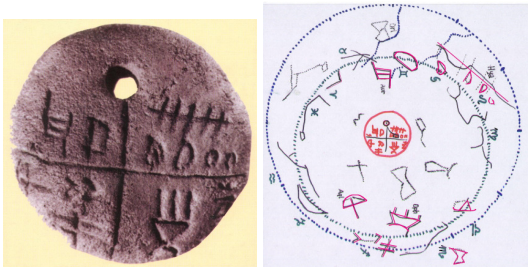

Fig. 4. Left: the Tartaria Disc. Right image: approximate position of the sky and the main constellations shown by their corresponding Sumerian signs on the left disc.

By constructing these early sky arrangements we can follow the main changes in the positions of the north celestial pole and the corresponding equator. The fixed coordinate in this reconstruction is the ecliptic, with the corresponding pole of the ecliptic in Draco. When we leave Earth, in the interplanetary voyages, the main coordinate point is that of the north ecliptic pole. This position is strengthened by the planetary system, where most of the planets orbit in the vicinity of the ecliptical equator.

Summary: Using an archeological find (the Tartaria disc) we can make more exciting the teaching of a special type of coordinate system: the ecliptic one. Horizontal and equatorial coordinate systems does not request stepping out from the Earth. So they do not need drastic change of view. However, using ecliptic coordinate system requests a new, an interplanetary viewpoint. We could recognize that the introduction of the 10 000 years time scale made it more familiar for the students the use of the ecliptic coordinate system. Benefits of this new view are: the celestial equator changes position – in 10 000 years scale – compared with ecliptic. Over the known mythic relations of the zodiac the approach of this new coordinate system to ecliptic is useful in the age of interplanetary voyages.

References: [1] Zanotti D.G. (1983): The Position of the Tărtăria Tablets within the Southeast European Copper Age. *American Journal of Archaeology.* Vol. 87, No. 2 (Apr., 1983), pp. 209-213 [2] Lazarovici, G., Merlini, M. (2005): New archaeological data refering to Tartaria tablets. *Documenta Praehistorica* 32:205-219. DOI: 10.4312/dp.32.16, [3] Záhonyi A. (2011): *A tatárlakai csillagóra. (The star-clock of Tatárlaka*). Fríg Kiadó, Piliscsaba; [4] Makkay J. (1970): *A tartariai (alsótatárlakai) táblácskák.* (The tablets of Tartaria.) *Magyar Tudomány 15*. I. 1970. 63-69.

Appendix: The constellations of the disc: Auriga, Gemini, Hydra (Raven, Goblet, Sequencer, Cancer), Libra, Wolf, Snake Holder, Southern Crown, Sagittarius, Eagle.

The constellations of the rectangular board containing the signs: Gemini, Auriga, Orion, Taurus, Pleiades, (Aries, Northern Triangle, Pisces), Andromeda, Pegasus.