

EARLY HISTORY OF SIMULATION IN EUROPE: SCALE PLANETARIUMS AND ASTROMORPHIC MODELS

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1 INTRODUCTION

The main idea of this paper is the following: simulation (as tradition and various tools and methods for understanding and representation of knowledge) takes much more significant place in the human history and culture and has essentially longer history, especially in Europe, than it was assumed traditionally. Various forms of graphical modeling of large-scale systems can be considered as typical examples from the early history of the European simulation. Scale planetariums and astromorphic models are the most interesting of them. The basic contents of this report are results of the researches done by the author since 1996 [1-6].

2 SCALED PLANETARIUMS

There are enough facts now to prove that at least some of the today known ancient stone and wooden rings were specific early form of simulation tools or environments for understanding and reproduction of real planetary movements long before Copernicus. The most famous is the Stonehenge, but there are some other good examples: first of all Windmill Hill (3100 BC) and Sarmizegethusa “circular shrine” in Rumania (100 BC) can be interpreted also as scaled models ($1:10^9$ and $1:10^{10}$ respectively) of solar system with the orbits of Earth, Venus and Mercury (Fig. 1).

Windmill Hill (Fig. 1b), near Avebury in Wiltshire (England) is a good example of a very early Causewayed Camp. The purpose of these camps is still uncertain although it is becoming clear that they were not, as originally thought, early markets or places of trading. Characteristic forms and the sizes of Windmill Hill allow putting

forward a hypothesis about its modeling purpose. It was, probably, one of the earliest scale planetaria in Europe and the world. However the lack of the facts yet does not allow proving this hypothesis convincingly enough.

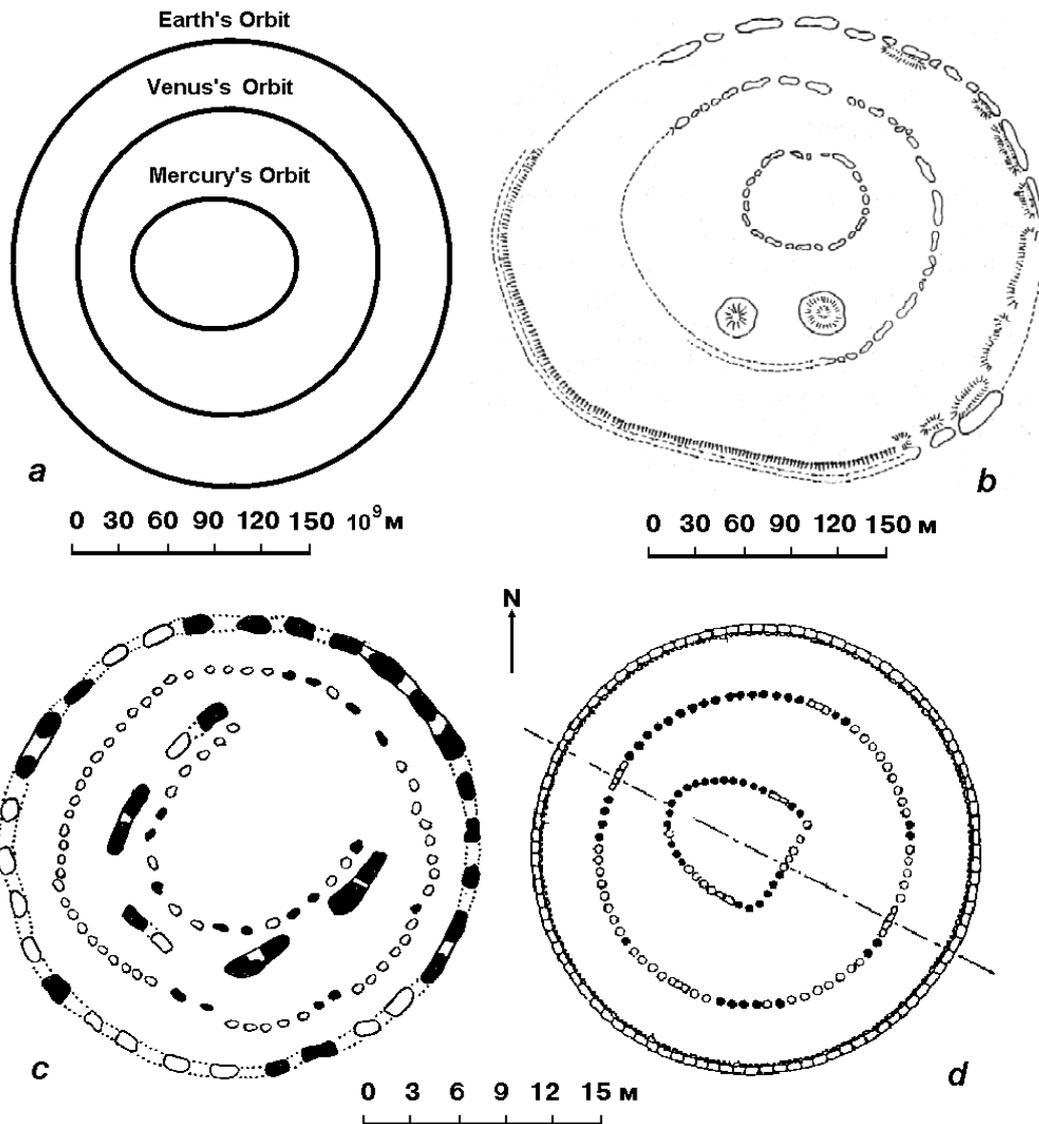


Figure 1. Real orbits the Earth, Venus and Mercury (a) and scaled models of solar system: Windmill Hill in England, 3100 BC, 1:109 (b); Stonehenge III, 2000 BC, 1:1010 (c); Sarmizegethusa "circular shrine" in Rumania, 100 BC, 1:1010 (d).

The situation with the Stonehenge is much clearer. Gerald Hawkins, an American astronomer, published the results of the intense study of the Stonehenge's astronomical alignments in Nature in 1963. In the article he described how he had used a computer to prove that

alignments between the Stonehenge and 12 major solar and lunar events were extremely unlikely to have been a coincidence. His book, “Stonehenge Decoded”, containing the fully developed theory, appeared in Britain in 1966 [7]. He discovered that lunar eclipses could be predicted through a system of moving seven stones around the circle of the Aubrey Holes (Fig. 2). Controversially, he went on to suggest that Stonehenge was a specific ancient computer.

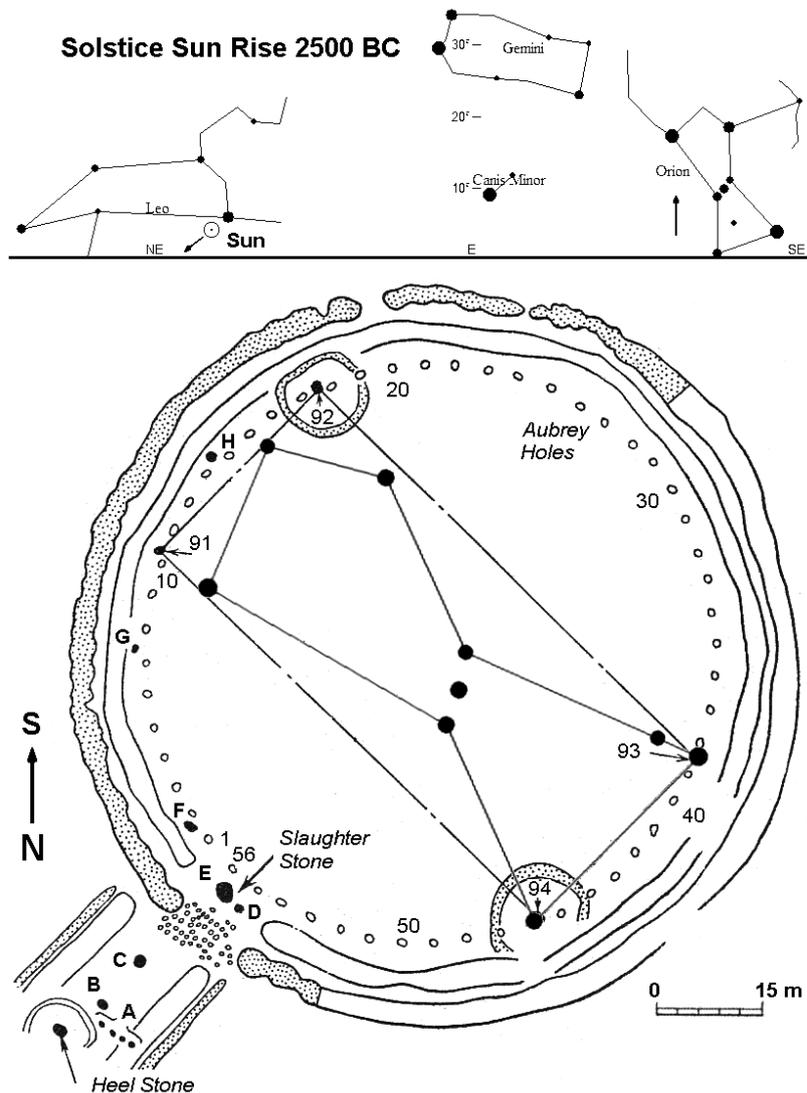


Figure 2. Aubrey Holes, Station Stones (91, 92, 93 and 94) and their possible astromorphic interpretation in Stonehenge I (2800-2500 BC)

Fred Hoyle, a Professor of Astronomy at Cambridge University, studied Hawkins' work and produced his own theories on more simple and realistic lunar predictions using the Stonehenge [8]. In his

scenario, Stonehenge became a Solar System model with the Earth at the centre. Rather than seven stones, Hoyle chose 3 stones representing the Sun, Moon, and one node of the Moon's orbit. The 3 stones were moved around the Aubrey Hole ring at their real rates relative to each other. When the 3 markers lay close together or almost opposite each other, the eclipse seasons took place.

It is possible to assume that long history of accumulation and analysis of knowledge in the form of special models has allowed determining some real parameters of the solar system long before invention of writing in traditional forms. Creation and use of various models and their mutual coordination has allowed to determine (with enough high degree of accuracy) sizes of the Earth, Moon and Sun, as well as the distance between them and five known planets. Figure 1c shows that early geocentric model in the Stonehenge I (2800-2500 BC) during further use and development has been transformed in a new heliocentric model (Stonehenge III, 2000 BC).

Process of use of such models for simulation of planetary motions can be reconstructed by the example of Sarmizegethusa “circular shrine” in Romania (100 BC) – the relatively later European analogue of the Stonehenge (Fig 3). The simulation of the Earth’s movement in this model is the most simple: each 2 days the marker moves on one of 180 elements of an external circle. The year correction is carried out either during the certain moments or as required. The simulation for Venus is a little more complex. The sidereal period for Venus is 224.8 days and can be simulated, for example, as $17 \times 3 + 3 \times 2 + 17 \times 3 + 4 \times 1 + 16 \times 3 + 3 \times 2 + 18 \times 3 + 4 \times 1 = 224$ with small correction each 4 years of five. Most interesting is the Mercury’s movement simulation. The sidereal period for Mercury is 88 days and can be simulated with the following elements of the orbits’s model: $21 \times 3 + 13 \times 2 = 89$ with one day correction as required. Planet’s marker was moved with various speeds in site “21” (one step each 3 days) and site “13” (one step each 2 days). It is almost exact simulation of different speed of the Mercury’s movement on the elliptic orbit with strong eccentricity.

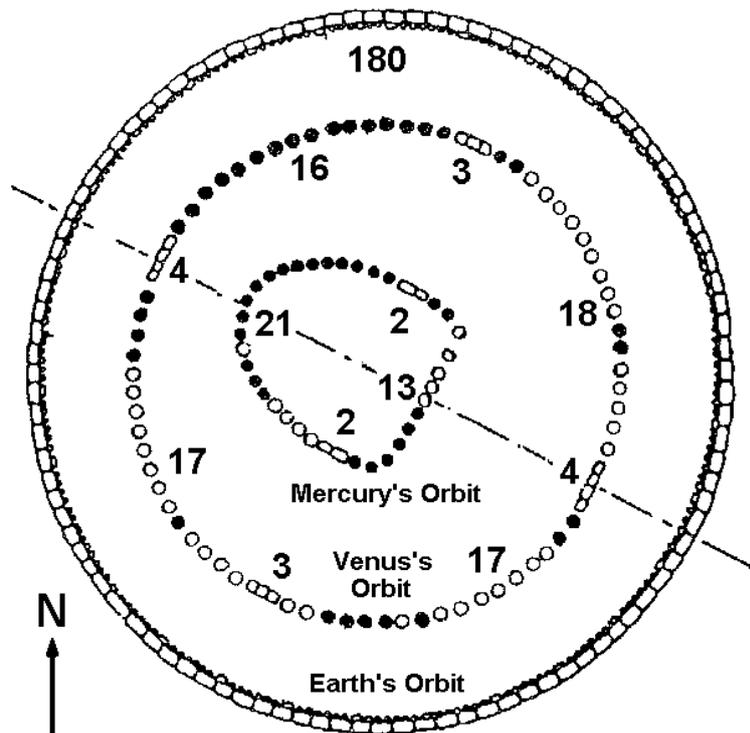


Figure 3. Main elements of Sarmizegethusa circular shrine for simulation Earth's, Venus's and Mercury's orbital motions

3 SCALED ASTROMORPHIC MODELS

Different scale astromorphic models are other important and interesting variant of the ancient simulation. "Astromorphic" means "corresponding (similar) to the arrangement of the certain bright stars in one or several of the most remarkable constellations" (Orion, Taurus, Virgo, etc.). The major attribute of such models is observance of the some simple enough scale conformity in the ratio the angular sizes of constellations and objects on the Earth. Early examples of such models are available in the Southern Russia, Ukraine, Near East and Crete (basically "terrestrial reflections" of Orion and Taurus) [2,5,6]. The most known of such reconstructions is work of Bauval R., Gilbert A. [9]. Information about this problem in context of archaeoastronomy can be found in some other publications (see, for example, [10]). The astromorphic elements can be also found in the Stonehenge I (Fig. 2).

But the most remarkable and large-scaled among such models is the medieval "star model" of Europe (Fig. 4). The arrangement of the main medieval cathedrals is the most important element of this model. Assumptions of arrangement of the main cathedrals of France on stars of constellation Virgo were known earlier [11]. However only now (on the base of modern computer simulation) it was possible to find the essentially more exact reconstruction of such conformity [5].

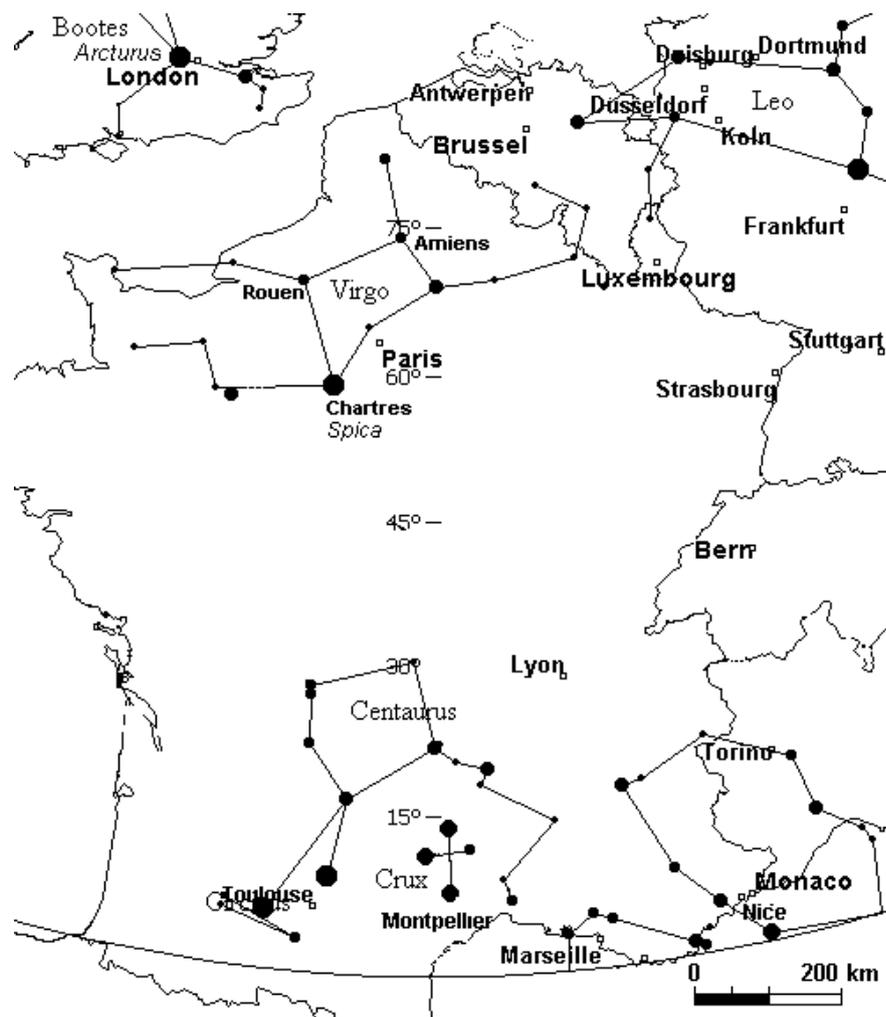


Figure 4. Medieval astromorphic model of Western Europe: Bootes – England, Virgo – France, Leo – Benelux and Germany

Two basic functions of such models are necessary to specify. The first function is especially practical: the organization of the space and simplification of terrestrial navigation under celestial maps. The

second function consists in realization of the certain religious ideas, and also - hermetic tradition which had huge influence on formation of the medieval and subsequent European culture (see, for example, [12]).

The place of Paris in this model can be connected with the position of the autumn equinox in the period T1 of Carolingian Dynasty (751-987) and so called Carolingian Renaissance (Fig. 5). Period T2 was the time of the most intensive cultural influence of this astromorphic model.

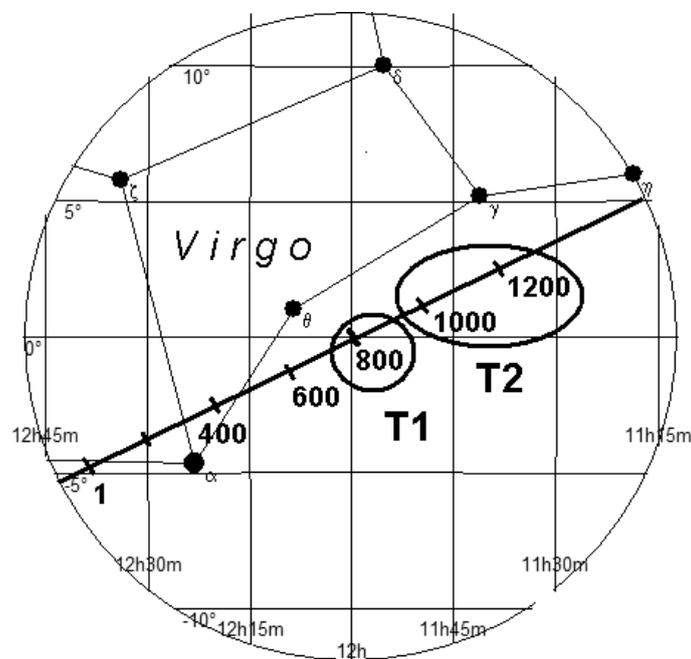


Figure 5. Positions of autumn equinox in 1-1200 AD (with grid for 800 AD)

The last period of development of such models was probably the time of Louis XIV (Sun King). The corresponding astromorphic elements can be discovered, for example, in plans of the Versailles (Fig. 6) and, most probably, in Paris.

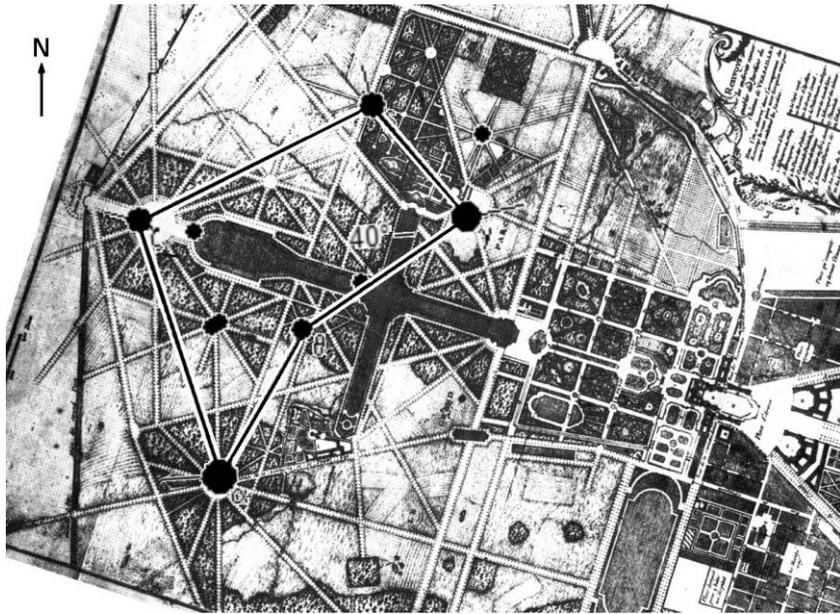


Figure 6. Possible astromorphic model in Versailles (1660)

ACKNOWLEDGEMENTS

The described models were not only tools of understanding and simulation of world around, but also served as the specific means for solving of the certain complex societal problems. Basic contribution of such models to the European development consists in entering of the order and high sense into the human activity. In such understanding they remain actual today.

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