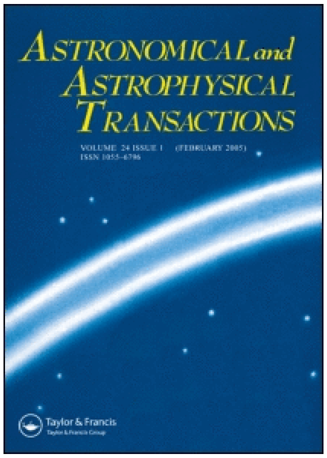

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THE BIRTH OF GRAVITATIONAL EVOLUTIONARY DYNAMICS OF STELLAR SYSTEMS (FROM Th. WRIGHT TO W. HERSCHEL)†

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Th. Wright, I. Kant and I. H. Lambert used well-known ideas about the structure and dynamics of the Solar system as a basis of their concepts of the stellar Universe. W. Herschel discovered the main features of the true, non-hierarchical large-scale structure of the Universe. He was also a pioneer of stellar dynamics with its new statistical laws and also of the theory of dynamical evolution in stellar systems at different scales.

A scientific approach to the problem of the structure of the Universe, its dynamics and even evolution at all scales has become possible since the formulation of the universal gravitation law by I. Newton (1687). The first ideas on the structure of the visible stellar Universe and on the nature of small milky nebulae as very distant stellar universes similar to ours were proposed at the first half of the 18th century, when Th. Wright (1711–1786) formulated his famous concept of the island Universe (1729–1750). He described our visible stellar Universe and each small milky nebula as sets of concentric, rather thin spherical stellar strata – "shells" (or rings like those of Saturn) with stars chaotically distributed in them (this is Wright's original idea of the "ordered disorder"). According to Wright, stars in each such stratum move around a common center of the parent system like planets move around the Sun; the visible image of the Milky Way is then only an optical illusion of an observer located inside such a stratum at some distance from its boundaries.

At the same time (1733), W. Durham noted an oblate elliptic shape of the most milky nebulae, while L. Maupertui (1742) was the first to explain this by a rapid rotation of the objects (however, he considered milky nebulae as individual heavenly bodies).

On this basis, I. Kant (1755) and, independently, I. H. Lambert (1761) proposed a universal theory of a hierarchical evolving island Universe and they considered the Milky Way as a real stellar system whose oblate shape is a result of rotation (this was appeied also to other similar stellar universes observed as milky nebulae).

†Conference held in Kosalma

The studies of the structure of the stellar Universe called for new statistical methods to be applied, based on probability concepts. The first who applied such methods was J. Michell (1744) who showed that the well-known stellar group, the Pleiades, cannot be an accidental phenomenon.

At the end of the 18th century W. Herschel (1738–1822) started his studies of the stellar Universe and the new great world of nebulae discovered by him (which he then believed to be other "universes") using his large telescopes and his original methods based on theory of probability (the "sweeping of the heavens" and "star gages").

Fundamental results of W. Herschel in this field are well known. He was the first who determined the general shape of our Galaxy and made an attempt to measure its size. He also discovered more than 2500 new nebulae, proved that stellar clusters are real physical objects (and introduced this term itself), and discovered physical binary stars.

Furthermore, Herschel made a number of other very important discoveries that were ahead of times and therefore were forgotten in history of astronomy. Herschel discovered basic elements of the large-scale structure of the Universe: the tendency of "nebulae" to cluster into "parcels" and to form extended "strata" which, according to his observations, may extend over great distances (1784). He borrowed the term "stratum" from works of natural historians (possibly, being influenced by then new evolutionary ideas in geology proposed by P. S. Pallas in 1777). Herschel (1784, S.P., vol. 1, p. 157) wrote: "In future, therefore, we shall look upon these regions into which we may now penetrate by means of such large telescopes as a naturalist regards a rich extent of ground or chain of mountains, containing strata variously inclined and directed, as well as consisting of very different materials."

This is actually the first description of a new, non-hierarchical large-scale structure of the stellar Universe. In particular, Herschel discovered and described in 1784 the richest and most extended nebulous stratum which he called the "stratum of Coma Berenices" (its densest parts was in two neighboring constellations of Coma and Virgo), and he considered plausible that this stratum "may surround the whole apparent sphere of the heavens not unlike the Milky Way" (Op cit., p. 165). This "stratum" turned out to be a part of the equatorial zone of the Local Supercluster of galaxies (discovered again by G. de Vaucouleurs in 1953).

Herschel proposed to consider this large-scale structure of the Universe (he believed at the time that all milky nebulae and even many clusters are individual remote stellar systems located outside the Milky Way) as a result of the evolution of cosmic matter governed by gravity (1785).

In 1784–1802 Herschel discovered dynamical systems of a new type, namely binary and multiple nebulae (in fact, 77 of them) and distinguished particular ones, whose components were connected with each other with nebulous bridges and immersed in a common envelope (we note that he believed these bridges and envelopes to consist of stars). This was the first indication of "interacting" galaxies (actually, 20 of them in the above sample), rediscovered as a new type of multiple galaxies by B. A. Vorontsov-Velyaminov in 1958, who also introduced this term itself.

Herschel proposed a new theory of formation and evolution of stellar clusters governed by gravitational forces (1785). His conclusion that steady "centers of clustering power" appear spontaneously in the stellar field and serve as seeds of future stellar clusters (1785, 1814) was an important first step in the further development of Newton's idea of dynamical instability in the initial chaotic distribution of stars in the stellar Universe.

Herschel discovered spherically symmetric density distribution in globular clusters with a sharp increase at the center and suggested the idea that the relative age of a cluster can be determined from its appearance (the morphological criterion of 1789). His conclusion was that globular clusters are the oldest among stellar clusters. We note that he considered most probable that globular clusters have empty dynamical centers (1802, vol. 1, p. 202). He considered stability of a cluster and was the first to attempt at the estimation of the age of globular clusters (10^8 years; 1785, Op. cit., vol. 1, p. 225).

Herschel noted complicated "deviations" in stellar motions within globular clusters associated with mutual perturbations produced by the stars; he concluded that this makes impossible the existence of inhabited planetary systems around cluster stars and suggested that such planets should be searched for around single stars (Op. cit., p. 201).

Herschel proposed a new idea of a final catastrophic stage in the evolution of a globular cluster when "stars had retarded in each others atmosphere, may rush at last together, and either in succession, or by one tremendous shock, unite into a new body" (Op. cit., p. 259). This was the first conjecture of the thermo-gravitational catastrophe, or collapse. Herschel suspected that the famous Tycho's star of 1572 in Cassiopeia might be a result of such a catastrophic event.

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DISCUSSION

Orlov: These ideas are very important now. The ideas of Th. Wright are close to the hypothesis of Professor A. Anselm (Institute of Nuclear Physics, St. Petersburg) on the Bose-condensate of arions in the very early Universe. The mass of arion is about 10^{-31} eV. This condensate forms a system of stagnation waves. Such a quasi-periodical structure was discovered in our work for the spatial distribution of quasars in the Catalogue of A. Hewitt and C. Burbidge.

The second comment concerning the sheet structure in the Universe. Such a structure was discovered by R. B. Tully *et al.* (1992) in the distribution of galaxy clusters. This structure was called a three-dimensional chess-board.