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RECENT DEVELOPMENTS IN MODELLING STAR COUNTS

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1. STAR COUNTS – INVENTORY OF THE STARS IN THE SKY

The number of stars in a given area of the sky, the star counts, are among the most elementary experiences of the astronomical observation. The progress of astronomy in the last centuries revealed that behind this elementary experience there is a complicated process of formation and evolution of celestial bodies in space and time and one observes only a projection, a "snapshot", onto the celestial sphere.

2. HISTORICAL OVERVIEW

In the 17th century Gallilei with his telescope discovered that the faint silver strip on the sky, the Milky Way, consists of a tremendous number of stars. In the 18th century based on this fact and using some heuristic arguments Kant suggested the first model of the spatial distribution and motion of the stars. His model, a slowly rotating disk, was capable to account for the general properties of the stellar distribution on the sky and explained why this spatial configuration did not crash due to the general gravitational attraction.

At the end of the 18th century W. Herschel attempted to reproduce the spatial distribution starting from the observed celestial distribution and apparent brightness of the stars. He concluded that the Galaxy is a 1:5 flattened system. At the beginning of this century Kapteyn evoked the old idea of Herschel and defined 206 fields (the system of Selected Areas) uniformly distributed over the sky, supplemented with 46 fields along the galactic equator. The resulting model, the "Kapteyn Universe", did not take into account the effect of interstellar absorption and resulted in a much smaller system of stars than we know today.

3. BASIC PROBLEM OF STELLAR STATISTICS

To reproduce the spatial distribution of stars from the observed celestial one and from the apparent brightness is the key problem of the stellar statistics. From mathematical point of view it means to solve the following integral equation for the spatial distribution:

$$A(m) = \omega \int_0^\infty D(r)\Phi(M,r)r^2 dr$$

where A(m) is the number of stars in the unit magnitude interval in the spatial angle ω, $D(r)$ is the spatial density and $\Phi(M,r)$ is the luminosity function of the stars at the distance r in the line of sight. For several reasons the ambitious program, deriving the spatial form of our Galaxy by solving the basic problem of stellar statistics, has never been completed. The results obtained so far are restricted to limited regions and sometimes quite controversial.

4. STAR COUNT MODELS

Instead of trying to reveal the entire Galaxy from the observed star counts the basic equation of stellar statistics might be used to model the observed distribution of the stars in the sky. For modelling star counts in this way one has to make some assumptions concerning the spatial distribution of the stars and the luminosity function.

The widely used model of Bachall and Soneira (1980) assumes that, similarly to other spiral galaxies, the Milky Way also consists of an exponential disk and a halo in the form of a de Vaucouleurs spheroid. The scale height of the exponential disk depends on the absolute magnitude of the stars in this model.

In order to model the distribution of the stars and galaxies on the sky in the near infrared Wainscoat et al. (1992) added to the exponential disk further components: the central condensation of our stellar system, the bulge, spiral arms and a torus-like distribution.

These models work remarkably well, however, there are still some systematic discrepancies between the observed and predicted counts.

5. EFFECT OF INTERSTELLAR ABSORPTION

In the previous models the distribution of the interstellar absorbing material was taken into account in the form of an exponential disk, i.e. the clumpy, cloudy distribution of the interstellar dust was fully ignored.

The presence of the interstellar dust, discovered by Trümpler (1930), makes the photometric distance of the stars apparently greater and their observed brightness dimmer than in the case of a fully transparent interstellar space. In this way the star counts are sensitive to the distribution of interstellar dust.

The departure from the model using smoothed interstellar absorption can be used for studying the distance and absorption of the interstellar dust clouds. This effect is much more significant in the visual domain than in the infrared because in the later the interstellar medium is more transparent, about a factor of 10.

6. NEW PERSPECTIVES

There is a revolutionary progress in getting a "Digital Sky" due to several new surveys. The "Digital Sky" is a huge database enabling the user to "observe" any part of the sky on the screen of his/her workstation. The Guide Star Catalog (limiting magnitude is about 14.5 in V) and the digitized Palomar Sky Survey are already available on compact discs. There are running (Deep Near Infrared Survey of the European countries), and well prepared (2MASS in the USA) projects in the near infrared which provide a homogeneous database for the southern hemisphere and for the whole sky. In the near future they open a new era also in using star counts for a better understanding of our Galaxy.