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# Star Chains and Dark Filaments in Galactic Nebulae

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WHEN investigating sufficiently dense star fields, one often finds some short chains of stars oriented with a certain regularity and in a few cases connected with dark filaments of the galactic nebulae. It is necessary to be very cautious in the interpretation of this phenomenon, because even completely accidental clustering of some objects can sometimes lead to interesting deviations from homogeneity.

This can be illustrated by the artificial star fields obtained by us in the following manner. Four-hundred black cards 3.5×3.5 cm in size were prepared. Every card was successively placed between electrodes of a Ruhmkorff coil and perforated over some time interval by means of electric discharges. The position of the card may be continually changed during the exposure. The direction of the spark is determined by random fluctuations in the conducting air layer between the electrodes. Each card becomes perforated during this procedure by nearly 250 extremely small holes. These cards were then successively exposed with a certain magnification on the same photographic plate. Negatives with many thousands of black dots of very minute sizes were obtained in this manner; the superposition of several negatives prepared independently permit one to obtain an artificial star field containing 100 000 or even more "stars" on an area of 10×10 cm.

Another method, perhaps a more trustworthy one, but much more slow in application, consists in denoting the rectangular coordinates obtained by means of registration of the position of a small ball in a rotating wheel (roulette).

The artificial star fields obtained in such a manner are characterized by noticeable irregularities. Sometimes short chains containing few stars and even oriented parallel to other similar chains in their close neighborhood are present.

The fluctuations of density, i.e., the fluctuations in the number of stars per unit area always occur, as it may be predicted with fair exactness, in accordance with the probability theory. Nevertheless, these fields of accidental objects never show any systematic streaming over a considerable area, as well as chains with intervals between the components much smaller than the mean distance between the stars of a given field. Such an artificial field is represented as an example in Fig. 1.* An area of 10×10 cm contains nearly 50 000 small dots distributed quite arbitrarily.

It may be concluded that only very close stellar chains may be considered with high probability as physically connected. But even in this case some additional arguments must be advanced in favor of this conclusion.

Figure 2 represents an example of a short chain containing about 7 stars very close together and apparently of the same color. This object was photographed with the Maksutov telescope of the Alma-Ata Astrophysical Observatory. It is situated in the neighborhood of the galactic nebula NGC 281 and its coordinates are

$$\alpha = 0^h\, 47^m{\cdot}4 \quad \delta = 56°\, 3'.$$

The scale of the figure is $1' = 13.8$ mm.

Analogous star chains are present in different parts of the sky, especially near the dark galactic nebulae. Very often they are intimately connected with extremely elongated dark filaments following them at some length. As a sufficiently conspicuous example the region of the gaseous nebula McDonald 12 in Cygnus can be indicated (see Fig. 3).

One can easily see numerous dark filaments in the same, approximately west-east direction. The width of these filaments is nearly 1′. One of them represents a narrow continuation of a very outstanding dark lane of the same orientation in the northern part of the picture.

In some parts of these filaments and at their border very narrow star chains are located, whose components are nearly of the same color. This can be demonstrated by comparing photographs taken in red and blue light, for instance by comparing the plates of the Palomar Atlas of the corresponding parts of the sky. Figure 4 represents our evaluation of the stellar magnitudes of five different star chains in the region of McDonald 12, using the charts of the Palomar Atlas. Some of these chains are indicated in Fig. 3, and more clearly in Fig. 5 (scale 20″/mm).

It may be noted that the color of all stars belonging to the same chain is almost always the same. Moreover, it is stated that bright star chains, namely of 13–14 mg, are characterized by a small color index corresponding to type $A$, but the fainter chains are considerably redder in appearance, having a color index equal to one or even one and a half.

What is the probability that these star chains are physically real? As was shown previously this probability in a very dense star field is very small from the

* Because of Dr. Fessenkov's absence on a scientific expedition in North Africa, the figures for this paper were not received prior to publication.

statistical point of view. But in reality we have some additional evidence pointing in favor of physical connections between the components of the same chain, namely, the similarity in color and the apparent connection with the dark filaments. This was also indicated recently by Martynov.[1]

If these systems are not accidental agglomerations of stars, they must be unstable and consequently very rare. Purely random arrangements of different kinds can surely appear in a dense star field. But their connection with dark filaments merits further attention.

Now a few words about the dark filaments, which are present in different parts of the sky, usually as some peculiarity of gaseous nebulae. It is to be noted that in the charts of the Palomar Atlas these filaments are much less distinguishable, because of numerous faint stars which appear in the area of the filaments.

By comparing these features, photographed with different exposures up to different limiting stellar magnitudes, one can evaluate the apparent decrease in the number of stars and consequently the corresponding absorption. This absorption is not very great and generally does not surpass one stellar magnitude.

In the case of the aforementioned dark filaments in the region of McDonald 12 in Cygnus, their width at a distance of 1000 parsecs corresponds to nearly 0.3 pc. It is reasonable to assume that their thickness in the line of vision is substantially the same. Adopting now that general absorption of light in this region of space is some 2–3 mg per 1000 pc, which corresponds to a density of the order of $6.10^{-26}$ g/cm$^3$, one can reach the conclusion that the density of the dust in the dark filaments may attain a value as high as $10^{-22}$ g/cm$^3$, or nearly 1000 times greater than the average for interstellar space. The probable presence of gaseous matter must increase the density still more.

[1] D. J. Martynov, Astron. Circ. N 149 (1954).

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# Microstructure of the Galactic Magnetic Field

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THE polarization of the stars in open clusters, explained on the basis of the Davis-Greenstein theory, gives some information on the microstructure of the galactic magnetic field.

The polarization is most conveniently described by the parameters $Q$, $U$, proportional to the Stokes parameters and defined by

$$Q=p\cos 2(\theta-\bar{\theta})$$
$$U=p\sin 2(\theta-\bar{\theta}),$$

where $p$ is the amount of polarization, $\theta$ is the position angle of the electric vector, and $\bar{\theta}$ is the mean value of $\theta$ for the region under consideration.

The parameters $Q$, $U$ may be represented as the integrals over the light path of some simple functions of the density and temperature of interstellar matter and of the components of the galactic magnetic field. We introduce two models: in the first model *isotropic* fluctuations are superimposed upon a homogeneous general magnetic field; in the second model fluctuations *perpendicular* to the mean direction of the field are superimposed upon a homogeneous field. The latter model might be correct if Alfvèn waves are running in the direction of the general field.

For each of these models the ratio of the variances of the parameters $Q$, $U$ is computed for a group of stars lying at the same distance in a direction approximately perpendicular to the direction of the general field. In this way for the first model, we have

$$\sigma_Q{}^2/\sigma_U{}^2=1+C^2>1, \quad (1)$$

while for the second model

$$\sigma_Q{}^2/\sigma_U{}^2=\tfrac{1}{4}\alpha_1{}^2+C^2. \quad (2)$$

Here $\alpha_1$ is the root-mean-square angular deviation of the magnetic lines of force from a uniform direction and $C^2$ is a positive constant.

The 92 stars within a radius of 2° around the Double Cluster in Perseus for which the polarization was measured by Hiltner[1(a)(d)], give

$$\sigma_Q{}^2/\sigma_U{}^2=0.60\pm0.14\text{(m.e.)}. \quad (3)$$

This value was obtained after eliminating the dependence of the polarization $p$ on the galactic latitude $b$; this dependence was represented by the linear formula

$$p=0.^m115(\pm0.007)-0.^m012(\pm0.002)|b|. \quad (4)$$

Since the ratio (3) is smaller than unity it cannot be explained by the first model, assuming isotropic

[1] (a) W. A. Hiltner, Astrophys. J. **114**, 241 (1951); (b) *ibid.* **120**, 178 (1954); (c) *ibid.* **120**, 367 (1954); (d) *ibid.* **120**, 454 (1954); (e) Astrophys. J. Suppl. **2**, No. 24 (1956).