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On the Origin of Double Stars

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SUMMARY
The problem of the origin of double stars is considered in the light of our recent knowledge of stellar associations.

IN our studies of stellar associations we concluded that the formation of stars is going on in the present state of our Galaxy. The expansion of newly arising groups of stars, suggested by this theory, was confirmed by BLAAUW and other astronomers. It is obvious now that stars are, as a rule, originating in groups and within comparatively small volumes. It is of extreme interest to discuss the origin of double stars in the light of new facts, relating to the group formation of stars.

The astronomy of double stars presents an inexhaustible store of observational facts. The majority of these will undoubtedly be utilized in future in order to develop a detailed theory of the origin of double stars. We shall mention here the following three important facts.

(1) As has been shown by us, there is no dissociative equilibrium in the Galaxy between double and single stars (AMBARTSUMIAN, 1937). The number of double stars is too large in comparison with the number that we should expect in the case of dissociative equilibrium. The number of double stars with semi-axes of orbits between 100 and 1000 astronomical units is about 10^8-times larger than it should be for dissociative equilibrium (AMBARTSUMIAN, 1947).

(2) The angular momenta of double stars about their centres of gravity are extremely large. They lie in the interval between values close to the angular momenta of stars with extremely high rotational velocity (close pairs) and values exceeding 1000 times the value of these angular momenta (wide pairs).

(3) There is no sharp difference between close and wide pairs, as long as the division of the double stars into visual and spectroscopic binaries is caused by the method of observation only. A future theory of the origin of double stars should, therefore, explain both the wide and the close pairs.

The first of the above-mentioned facts refutes the suggestion concerning the origin of double stars (at least of those double stars that we observe) as a result of capture in the galactic stellar field. We mention here only such captures which could take place at triple encounters. As soon as, by virtue of the process of capture, the percentage of double stars reaches the value predicted by the theory of dissociative equilibrium, no further increase should take place, because the number of pairs originating as a result of the capture should be equal to the number of pairs which are being dissolved as a result of opposite processes (encounters of a pair with a field star).

The second and the third facts refute the suggestions of the origin of double stars

as a result of fission of individual stars. In accordance with the law of conservation, the momentum of a pair according to this hypothesis cannot exceed the angular momentum of individual stars with extremely high velocities of rotation. This, however, contradicts the large angular momenta of wide pairs.

Our conclusions concerning the incorrectness of the hypothesis of capture, as well as of the fission hypothesis of an individual star, are only valid as long as we may disregard the effect of external influences on the development of a double star in the course of its life after the time of origin.

Mentioning external disturbances we must bear in mind two probable types: disturbances caused by approaching field stars, and the influence of the interstellar medium.

If disturbances caused by field stars passing in the vicinity of a double star are very large, they might be expected, first of all, to lead to dissociative equilibrium. The observed strong deviation from dissociative equilibrium, however, points to the insignificant rôle of such disturbances, at least in the case of pairs with large orbital semi-axis up to 10,000 astronomical units. Such causes could therefore hardly play any essential rôle in the establishment of the observed law of distribution of the angular momentum and of the orbital elements of double stars. The influence of external factors could be important in the case of wide pairs with distances over 20,000 astronomical units. Such pairs do not, however, play an essential part in the astronomy of double stars.

The influence of accretion from the diffuse interstellar medium was studied by HOYLE. It should lead to a decrease of the major axis of the orbit, in consequence of which wide pairs should become close and the components should become more massive. It might be supposed, therefore, that double stars are formed, to begin with as extremely wide pairs as the result of a capture, with major semi-axes of the order of 10^5 astronomical units; afterwards they change, owing to accretion, into closer pairs, having no time to be destroyed by the passage of neighbouring stars.

Observations show that there exist triple stars of the following structure: around the massive main star, and at a great distance from the latter, rotates a close double star consisting of two satellites of small mass. An example of such a triple star might be β Orionis. It follows, from the point of view of the accretion theory, that the central star having greatly increased its mass, could not bring its faint satellites nearer while the faint satellites could approach in spite of the small increase in their masses.

In this case it is also rather difficult to explain the existence of more or less close pairs consisting of dwarfs.

We should, thus, reject altogether the hypothesis of capture as a result of occasional triple encounters in the galactic stellar field, as also the fission hypothesis of individual stars. The only possible conclusion is to admit a common origin of the components of a double star from the pre-stellar state of matter. Such a conclusion agrees well with the assumption of the group-formation of stars. One should admit that when stars in associations are originating in groups, double stars are formed as well.

The following facts point in favour of the above-mentioned view: (1) we observe in associations of hot giants (O-associations) a considerable number of both wide and close pairs (the number of triple and multiple stars is also great); (2) we observe among the members of T-associations an unusually high percentage of visual pairs.

It thus seems quite probable that some stars originate during the formation of stellar groups as pairs, triplets, quartets, *etc.*

Can we develop this supposition in greater details just at the present time? We believe that a further investigation of stellar associations will permit us to do so in the immediate future.

There exists, however, one circumstance to which attention should be paid even at present, and which we consider to be of the utmost significance.

In some stellar associations we observe multiple systems of the Trapezium Orionis type. Systems of this type are multiple stars, such that in them we can distinguish at least three components with distances between them of the same order of magnitude. I suggested, in conjunction with MARKARJAN, that a considerable part of the Trapezium type systems might possess positive energies. This means that such systems should dissociate directly. It was shown by PARENAGO (1953) that observations of the Orion Trapezium carried out during more than 100 years demonstrated that its energy is definitely positive. Thus some multiple stars originate in associations as systems with positive energies.

The excess of double stars in associations allows us to suppose that some such stars dissociate before they leave the association. If so, and if the ordinary double stars which occur in the galactic field originate in association, then the following conclusions arise naturally: there originate in associations, besides pairs with positive energies, also pairs with negative energies; pairs with positive energies dissociate within the association, or in its vicinity; those with negative energies, after leaving the associations, transform into ordinary double stars of the main stellar field.

These are the first conclusions which we draw on the basis of the new idea concerning the origin of double stars.

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