FROM DARK CLOUDS TO PLANETS AND SATELLITES, H. Alfvén
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An intermediate state in the evolutionary chain from dark clouds to planets-satellites is reconstructed. Two independent methods are used:

A. Reconstruction from solar system data

In order to reduce speculation to a minimum, the problem is approached in a new way which is characterized by the following principles (see ref. (1)):

1. The actualistic principle

This avoids arbitrary assumptions about the early state of the solar system, which instead is reconstructed from a detailed analysis of the present state and of the possible experimentally verified processes which may have led to it.

2. The hetegonic principle

This could also be called "comparative planeto-satellitology". As has been demonstrated in ref. (1), this is a very powerful method for discriminating between probable and improbable processes and for reducing speculation.

3. The principle of extrapolation of mechanisms

The study of plasma physics has given us the sobering experience that it is almost impossible to predict the actual behavior of a plasma through purely theoretical calculations starting from basic principles. The properties of a plasma can be understood only by very sophisticated diagnostic studies based on in situ measurements. Such measurements are now possible in the laboratory and in the magnetosphere-heliosphere.

However, neither for phenomena in distant regions of space which are inaccessible to spacecrafts, nor for cosmogonic phenomena is in situ diagnostics possible. Under such conditions the most reliable method of approach seems to be to compare phenomena in non-accessible regions with similar phenomena in the magnetosphere or in the laboratory and treat them as extrapolations of well-known phenomena. Examples are: The transfer of angular momentum from a spinning central body can be studied by comparing it to similar mechanisms in the magnetosphere. The band structure of the solar system may be clarified by laboratory studies of the critical velocity phenomenon.

An analysis of solar system data, largely supplied by space research, has resulted in the reconstruction of an intermediate state in the evolution of the solar system as shown in Fig. 1. Instead of a thin flat disc, which is hypothetically introduced in some theories, our reconstruction results in two toruses containing accreting grains and planetesimals which do not necessarily move in circular orbits but in orbits with eccentricities up to $e = 1/3$ and inclinations up to about 30°.

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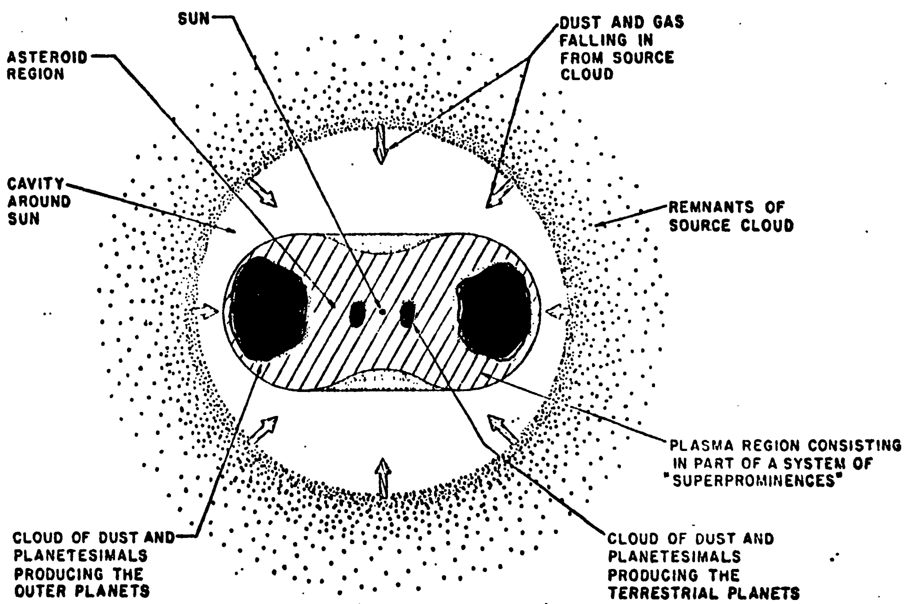
Fig. 1



B. Reconstruction from dark cloud observations

It is very likely that solar systems of the same type as ours are formed in dark interstellar clouds. Magnetic fields are of decisive importance for their evolution but electromagnetic effects do not necessarily counteract the contraction of a cloud; they may just as well "pinch" the cloud. Magnetic compression may even be the main mechanism for forming interstellar clouds and keeping them together (see ref. (2)).

Further, star formation is likely to be due to an instability, but it is unlikely that it has anything to do with the Jeans instability. A probable mechanism is that the sedimentation of dust (including solid bodies of different sizes) is leading to a rapid gravitationally assisted accretion. A "stellesimal" accretion analogous to the planetesimal accretion can be expected to lead to the formation of a star surrounded by a low density cavity in the cloud. Matter falling in from the source cloud towards the star is stopped when the critical velocity is reached, and constitutes the raw material for the formation of planets and satellites.

The study of the evolution of a dark cloud leads to a scenario of planet formation which is reconcilable with the results obtained from studies based on solar system data. In fact Fig. 1 can just as well be presented as a result of the evolution of a dark cloud according to ref. (2).

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C. Conclusion

An analysis of the processes in dark interstellar clouds studied in ref. (2) together with the processes studied in ref. (1) lead to a consistent framework for theories describing the evolutionary chain starting from the formation of a cloud and ending with planets and satellites with the present properties.

References

(1) Alfvén, H. and Arrhenius, G. (1976) Evolution of the Solar System, NASA SP-345.

(2) Alfvén, H. and Carlqvist, P. (1978) Interstellar Clouds and the Formation of Stars, Astrophy. and Space Sci., in press.