COSMOGONY AS AN EXTRAPOLATION OF MAGNETOSPHERIC RESEARCH

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(Received 26 March, 1984)

Abstract. A theory of the origin and evolution of the Solar System (Alfvén and Arrhenius, 1975, 1976) which considered electromagnetic forces and plasma effects is revised in the light of new information supplied by space research. In situ measurements in the magnetospheres and solar wind have changed our views of basic properties of cosmic plasmas. These results can be extrapolated both outwards in space, to interstellar clouds, and backwards in time, to the formation of the solar system. The first extrapolation leads to a revision of some cloud properties which are essential for the early phases in the formation of stars and solar nebulae. The latter extrapolation makes possible to approach the cosmogonic processes by extrapolation of (rather) well-known magnetospheric phenomena.

Pioneer-Voyager observations of the Saturnian rings indicate that essential parts of their structure are 'fossils' from cosmogonic times. By using detailed information from these space missions, it seems possible to reconstruct certain events 4–5 billion years ago with an accuracy of a few percent. This will cause a change in our views of the evolution of the solar system.

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1. Introduction

This paper is a brief review of work on cosmogony (evolutionary history of the solar system) which began in 1942. The new idea was that electromagnetic (or hydromagnetic) effects were of decisive importance for understanding how the solar system got to its
present state. Because previous cosmogonies since Laplace considered mechanical forces alone, this was not reconcilable with the generally accepted types of cosmogonies. Certainly, these have changed drastically during the ages, but almost all of them neglected hydromagnetic and plasma effects. Few cosmogonists had more than a superficial knowledge of hydromagnetics and plasma physics, with the result that the decisive importance of the 2:3 contraction and the band structure have not been appreciated.

Space research has now changed the situation by giving us new information about electromagnetic and plasma effects in space. From in situ measurements in the magnetospheres we know the properties of plasmas over five or ten orders of magnitude in density, in magnetization, in temperature, etc. and we also begin to understand what processes are possible and which are not. This has introduced or is introducing a new climate in cosmical physics which may be more favorable for a serious discussion about the evolutionary history of the solar system.

1.1. NEW PARADIGM

The foundations of a space age cosmic plasma physics, which now must be slowly built up, are essentially the following:

(a) The electromagnetic spectrum can now be observed outside the atmosphere, which means that the number of octaves available has increased by more than a factor of two.

In the field of plasma physics we have especially to note that large parts of the newly discovered astrophysical phenomena – for example, in X-ray and gamma-ray astronomy – are obviously due to plasma phenomena. Still more important are

(b) In situ measurements in the magnetospheres (including the heliosphere).

(c) Laboratory studies of phenomena of interest in cosmic plasma physics.

(d) Increased understanding of how to extrapolate results obtained in one field to other fields of plasma physics.

A survey of some of the ‘paradigm transitions’ which this has caused or is causing has been published in a monograph (Alfvén, 1981a). Summaries of this have been presented in Alfvén (1982, 1983a c).

The following table (Table I, essentially the same as published in a Geophysics Research letter (Alfvén, 1983a)) is a catalogue of the fields which are up for revision.

1.2. CONSEQUENCES FOR COSMOGONY

For cosmogony this has led – or is inevitably leading – to a new approach. We do not need to base cosmogonic theory on more or less reasonable assumptions about conditions at the time when the solar system was formed (probably 4–5 G years ago), or on uncertain interpretations of distant, marginally observable phenomena. We can instead treat cosmogony as an extrapolation of reasonably well-established processes from space research, often derived from in situ measurements (see Figure 1). The result is an approach in which the evolutionary history is decided by a combination of mechanical effects and electromagnetic (plasma) effects.