



## **The Choice of the Concept of Magnetic Field Lines or of Electric Current Lines (Hannes Alfvén Medal Lecture)**

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In 1967, at the Birkeland Symposium in Sandefjord, Norway, Professor Hannes Alfvén stated that the second approach (in solving unsolved problems by the standard MHD theory) to cosmic electrodynamics is to "thaw" the "frozen-in" magnetic field lines. He stated: "We can illustrate essential properties of the electromagnetic state of space either by depicting the magnetic field lines or by depicting electric current lines".

It was my first experience of attending an international symposium, and there I had an opportunity to meet Alfvén for the first time. Unfortunately, although there has been much progress in space physics since then, our scientific community has not really succeeded in thawing the frozen-in field lines even 40 years after the Birkeland symposium, and has pursued magnetic reconnection. Alfvén had been critical about the concept of magnetic reconnection.

I will here discuss crucial magnetospheric and solar observations in terms of Alfvén's electric current concept that can provide physical insight into many of our unsolved problems, such as substorm onset processes, the substorm current system, the storm-substorm relation, sunspots, solar flares, coronal mass ejections, the interplanetary current sheet and the magnetic field configuration of the heliosphere. Alfvén's concept is important before attempting to solve the related MHD equations or perform numerical simulations.

Alfvén and Sydney Chapman had a long debate, but actually both were correct in the sense that a pencil has two ends. Chapman emphasized one end, the plasma aspects of the solar stream, while Alfvén stress the other end, the importance of the interplanetary magnetic field. Combining both, we have the present concept of the magnetosphere. I believe that we have to study many unsolved problems in terms of both the magnetic field line concept and the current system concept.