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# Metastability of collisionless current sheets. Hannes Alfven Lecture on behalf of Albert Galeev

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Complicated magnetic configurations containing numerous magnetic field reversals are widespread in nature. Each of such reversals is supported by corresponding current sheet (CS) which could often have very small thickness comparable to ion skin depth. Since the beginning of Space Age "in situ" investigations of current sheets in the Earth's magnetosphere (magnetopause and magnetotail) acquired one of the highest priorities in national space programs and became one of the cornerstones of various international activities, like ISTP, IACG, and ILWS, which appeared to be very effective. Intense theoretical efforts were undertaken by theorists all over the world to develop both equilibrium models of current sheets and analyze its stability and further nonlinear evolution. Lack of collisions and smallness of many characteristic scales in comparison with ion Larmor radius made an application of straightforward MHD approach dramatically questionable. Professor Alfven was one of the first who suggested in 1968 simple but very physical self-consistent particle model of CS.

One of the most intriguing features of current sheets in collisionless plasma is their ability to accumulate tremendous amounts of magnetic energy ($10^{15}$ J for magnetospheric substorms , $10^{24}$ J for solar flare associated sheets) and then suddenly sometimes almost explosively release them. We will demonstrate in this talk that such METASTABILITY is a principal intrinsic feature of current sheets in hot plasma. Very intense theoretical debates of 80-ies and late 90-ies resulted in some consensus that current sheets with the small component of magnetic field normal to their plane become overstable for spontaneous reconnection (i.e. versus the development of ion tearing mode). Analysis of INTERBALL and especially 4- point CLUSTER data have shown that real current sheets observed in the Earth's magnetotail very rarely resemble simplistic HARRIS current sheets which have been used for an early stability calculations. Realistic effects taken into account (anisotropy, embedding, layering, bifurcations) already produce picture consistent with observations.
Metastable sheets acquire narrow, but finite windows of instability, which once started produces at its nonlinear stage irreversible modification of magnetic topology resulting finally to the release of a stored magnetic energy. Satellite observations could verify this concept potentially very important for other applications in space and laboratory.

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