Reconnection in magnetic and vorticity fields

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Reconnection is an important process of structure formation in fluid dynamics. It occurs in form of vortex reconnection in hydrodynamics as well as in form of magnetic reconnection in plasmas. In both cases the process leads to a change in the topology of field lines, which can in turn trigger a major conversion of energy, as for example seen in the eruptions of solar flares.

At first the process of reconnection is described in its most general form, that is as a particular evolution of a divergence-free field embedded in a fluid. This description can be applied to magnetic fields as well as vorticity fields and it does not refer to any particular form of dissipation which is necessary to drive the process. It distinguishes the very special two-dimensional reconnection, that is a reconnection process which is approximately invariant in one spacial direction, from the generic, but more complicated three-dimensional case. These two types also differ with respect to their effect on the total helicity of the divergence-free field. It is shown that the two-dimensional reconnection preserves the total helicity while in the three-dimensional case the source term of helicity is non-vanishing. However, even in the latter case the effect of reconnection on the topology of the field is a very particular one and this allows for statements on how helicity is generated in reconnection processes.

Simple analytic examples of magnetic reconnection and vortex reconnection are given to demonstrate similarities and differences of both cases. Especially it is shown that while for magnetic reconnection simple two dimensional stationary solutions exist vortex reconnection always requires a time-dependent velocity field. Moreover there are no true two-dimensional solutions for vortex reconnection. This explains why vortex reconnection in spite of all similarities has a much more complicated geometry than magnetic reconnection.