Geophysical Research Abstracts
Vol. 14, EGU2012-1661, 2012
EGU General Assembly 2012

Soft iron and axisymetric eigenmodes in the von-Karman-Sodium dynamo

A. Giesecke, F. Stefani, and G. Gerbeth
Helmholtz-Zentrum Dresden Rossendorf, Magnetohydrodynamics, Dresden, Germany (a.giesecke@hzdr.de)

In the Cadarache von-Karman-Sodium (VKS) dynamo experiment magnetic field excitation is generated by a turbulent flow of liquid sodium. In the experiment this so called von-Karman-like flow is driven by two counter-rotating impellers that are located close to the end-caps of a cylindrical vessel.

Despite of extensive numerical and experimental efforts the very nature of the VKS dynamo and its surprising properties still remain unclear. Firstly, dynamo action is obtained only when (at least one of) the flow driving impellers are made of soft iron with a relative permeability around 65. Moreover, and in apparent contradiction with Cowling's anti-dynamo theorem, the geometric structure of the observed magnetic field is dominated by an axisymmetric field.

Our kinematic simulations of an axisymmetric model of the Cadarache dynamo show a close connection between the exclusive occurrence of dynamo action with soft iron impellers and the axisymmetry of the magnetic field. We observe two distinct classes of axisymmetric eigenmodes, a purely toroidal mode that is amplified by paramagnetic pumping at the fluid-disk interface and a mixed mode consisting of a poloidal and a toroidal contribution that is rather insensitive to the disk permeability. In the limit of large permeability, the purely toroidal mode is close to the onset of dynamo action with a growth-rate that is rather independent of the flow field. This mode is located near to and in the high permeability disks and becomes the leading mode when the disk permeability exceeds a critical value. However, since in our axisymmetric configuration the purely toroidal mode is decoupled from any poloidal field component no dynamo action can be expected from this mode. The purely toroidal mode and its strong amplification by paramagnetic pumping at the fluid-disks interface can be obtained only by explicitly considering the internal permeability distribution. This mode does not exist in case of highly conducting disks or in simulations that only apply idealized boundary conditions.

The separation into purely toroidal and mixed mode can be overcome e.g. by a non-axisymmetric permeability distribution that resembles an assembly of blades attached to the disks. Such a coupled eigenmode is even more likely to facilitate the occurrence of dynamo action when a further source term like the alpha-effect is considered that is necessary to break the restriction imposed by Cowling's theorem. The particular coupling mechanism provided by such a non-axisymmetric permeability distribution might give a hint why dynamo action is absent in experiments when the fluid flow is driven by an impeller system composed of soft iron disks and stainless steel blades.