EURO MHD 2008

Nice : 23-26 September

Web page: http://www.oca.eu/euromhd2008/

This conference aims at gathering scientists working on general MHD phenomenas, dynamo instabilities, and magnetic rotating fluids.

sponsors : **CNRS** (INSU/PNST, INSU/PCMI, Fr W. Doblin, GDR Dynamo),
Observatoire de la Côte d'Azur, **Conseil Général des Alpes maritimes** .

Organizers : Y. Ponty, E. Dormy, H. Politano, S, Szeles

Scientific Program :

For all talk 20 min (include questions)

Tuesday 23th September :
13h50 : Welcome and informations

Experimental Dynamo session *(Charmain : F. Daviaud)*

14h00 :
P. Roberts -- Numerical simulation of a spherical dynamo excited by a flow of von Karman type
C. Gissinger -- Modelisation and simulations of dynamo experiments
C. Guervilly -- Numerical simulations of spherical Couette dynamos
15h00 :
C. Nore -- Impact of impellers in the VKS2 dynamo experiment
A. Giesecke -- Kinematic dynamos in cylindrical geometry
J. Léorat -- MHD problems in heterogeneous domains with conducting and permeability jumps
16h00 coffee break
16h30 :
F. Petrelis -- Excitability in the vicinity of a saddle-node bifurcation: a mechanism for reversals
G. Verhille -- Velocity Measurement in a Screw Flow
N. Plihon -- The synthetic Bullard-Von Karman dynamo
N. Leprovost -- Dynamo quenching due to Shear

18h00: Welcome "aperitif"

Dinner in town

Wednesday 24th September :

9h30 : Rotating fluid and MRI session *(Chairman : P. Cardin)*

W. Herreman -- Kinematic dynamo of inertial waves

D. Schmitt -- Magneto-inertial waves in a rotating fluid sphere

L. Petitdemange -- Magnetostrophic MRI in the Earth's Outer Core

10h30 coffee break

11h00 :

C. Forest -- Numerical Simulations of a Plasma Dynamo and MRI Experiment

F. Cattaneo -- MRI driven turbulence and dynamo action

G. Ruediger -- MRI and Tayler instability in the laboratory

12h00 Lunch (Maison du seminaire)

13h30 : Poster session

14h00 : Turbulence MHD (Chairman : H. Politano)

A. Newton -- Numerical Investigation into sheared MHD turbulence

T. Yousef -- New results on dynamo action in sheared and rotating turbulence

I. Rogachevskii -- Nonhelical mean-field dynamos in sheared turbulence

15h00

A. Alexakis -- Modeling anisotropic MHD turbulence

J. Baerenzung -- Spectral modeling of magnetohydrodynamic turbulent flows

A. Schekochihin -- Saturation of small-scale dynamo and spontaneous formation of current sheets

16h00 Coffee Break

17h00 :

D. Hughes -- Dynamos driven by Shear and Turbulent Convection

A. Pouquet -- Waves and turbulence in MHD

17h40 :

Dinner in town

Thursday 25th September :

Astrophysics session (Chairman : A. Pouquet)

9h00 :

S. Mathis -- Magneto-Gravito-Inertial waves in strongly stratified stellar interiors

T. Rogers -- The interaction of Internal Gravity Waves and Magnetic Fields

P. Garaud -- The solar tachocline

W. Kuang -- Variation of the Dynamo domain and sudden termination of Mars Dynamo

10h30 coffee break

11h00 :

C. Jones -- Zonal flows and Jupiter's dynamo

K. Kuzanyan -- Compressible convection in rapidly rotating spherical atmospheres of giant planets

L. Goudard -- Dynamo-Region Geometry Controlling Stars and Planets Magnetic Behavior

12h00 Lunch (Maison du seminaire)

13h30 poster session

14h00 : Fairly Mathematical session *(Chairman : S. Childress)*

R.L. Ricca -- On the groundstate energy of knotted magnetic flux tubes

S. Tobias -- How do dynamos saturate?

F. Plunian -- Oscillating Ponomarenko dynamo in the highly conducting limit

15h00 :

K.H. Radler -- Mean-field effects in the Galloway-Proctor flow

A. Shukurov -- Flux rope dynamos

D. Sokoloff -- Magnetic field in fluctuating ABC flow

16h00 Coffee Break

16h30 :

M. Proctor -- Interactions Of An Unstable Shear Flow With A Convectively Unstable Region

A. M. Soward -- Shear-layers in magnetohydrodynamic spherical Couette flow with conducting walls

18h30 Social event : Conference Dinner : Aston Hotel

Friday 26th September :

9h00 : Geophysical session and misc (C. Jones)

V. Morin -- Numerical investigation of the dynamo bifurcation in Geodynamo Models

D. Jault -- *Quasi-geostrophic modelling of the geomagnetic secular variation*

P. Cardin -- Experimental measurements of Alfven waves in a liquid metal

B. Bigot -- Development of anisotropy in incompressible MHD turbulence

10h30 :

11h00 :

H. Homann -- Clustering of passive impurities in MHD-turbulence

E. Dormy -- Time scales separation for dynamo action

Y. Ponty – Dynamo simulation inside Pseudo-Penalisation Boundaries

Conclusions and end of the conference

12h00 Lunch (Maison du seminaire)

Posters :

R. Avalos-Zuniga -- Oscillating homopolar disk-dynamo

M. Berhanu -- Oscillations to reversals in the Von Karman Sodium dynamo.

A. Courvoisier --The influence of spatial coherence on mean induction and diffusion.

N. Gagnière -- The modified Taylor's state with turbulent Ekman layers and comparison with experimental results.

L. Garcia de Andrade -- Stretching dynamos in compact curved Riemannian spaces

C. Gissinger -- Numerical simulation of galactic dynamo.

A. Jackson -- Simple 3-D Taylor State Models of Earth's Core

W. Mouhali -- Cyclonic vortex regime in a precessing cylinder flow

C. Normand -- Modal versus energetic stability of cylindrical kinematic dynamos.

R.L. Ricca -- A simple kinematical model for Stretch-Twist-Fold dynamo.

L. Silvers -- Long-term nonlinear behaviour of the magnetorotational instability in a localized model of an accretion disc.

T. Wood -- Magnetic confinement in the Solar Interior

A. Alexakis
ENS Paris (France).

Modeling anisotropic MHD turbulence

I will discuss current theories of anisotropic MHD turbulence. A non-local cascade model for anisotropic MHD turbulence in the presence of a guiding magnetic field will be proposed that takes into account that (a) energy cascades in an anisotropic manner and as a result a different estimate for the cascade rate in the direction parallel and perpendicular to the guiding field is made. (b) the interactions that result in the cascade are between different scales. Connections with numerical experiments and the question of universality of the energy spectrum will be discussed.

R. Avalos-Zuniga
Universidad Autonoma Metropolitana-Iztaplapa, (Mexico).

Oscillating homopolar disk-dynamo (poster)

We report on the linear stability analysis of the modified Bullard disk-dynamo in which the disk rotation rate is subject to harmonic oscillations. The problem is governed by a damped Mathieu-type equation. Firstly, we show that dynamo can be exited by the parametric resonance mechanism at strongly subcritical disk rotation rates. Secondly, at supercritical rotation rates, dynamo can also be suppressed, like the stabilization of inverted pendulum, by a proper choice of frequency and amplitude of parametric forcing. We calculate the Floquet exponents which define the growth rates of magnetic field depending on the amplitude and frequency of disk oscillations, and find the critical amplitude of the forcing depending on the frequency at various values of the dynamo parameter. In addition, we analyze the temporal structure and spectra of the induced magnetic fields in various dynamo regimes.

J. Baerenzung
NCAR boulder (USA)

Spectral modeling of magnetohydrodynamic turbulent flow

I will present a dynamical spectral Large Eddy Simulation (LES) model for the incompressible magnetohydrodynamic equations based on the Eddy Damped Quasi Normal Markovian (EDANM) equations. This model extend classical Large Eddy Simulations for the Navier-Stokes equations to incorporate general (non Kolmorovian) spectra as well as eddy noise.
A new eddy-damping time was derived for the EDQNM equations and then added into the LES model, improving the results we obtained.

M. Berhanu
ENS Paris (France)

Oscillations to reversals in the Von Karman Sodium dynamo. (poster)

VKS experiment is the first one displaying, dynamical regimes of the magnetic field generated by dynamo effect. In particular reversals of the magnetic field similar to the ones recorded for the Earth magnetic field on the geological time scales. In recent experiments, we showed that this particular behavior is associated to a transition between an oscillatory dynamo and a stationary dynamo. Our observations allow to discriminate between different models of reversals.

B. Bigot
Observatoire de la Cote D'azur (Nice).

Development of anisotropy in incompressible MHD turbulence

We present a set of 3D direct numerical simulations of incompressible decaying MHD turbulence in which we investigate the influence of an external uniform magnetic field B_0. A parametric study in terms of B_0 intensity is made where, in particular, we distinguish the shear- from the pseudo-Alfven waves dynamics. The initial kinetic and magnetic energies are equal with a negligible cross-correlation. Both the temporal and spectral effects of B_0 are discussed. A sub-critical balance is found between the Alfven and nonlinear times with both a global and a spectral definition. The nonlinear dynamics of strongly magnetized flows is characterized by a different k_perp-spectrum (where B_0 defines the parallel direction) if it is plotted at a fixed k_\\ (2D spectrum) or if it is integrated (averaged) over all k_\\ (1D spectrum). In the former case a much wider inertial range is found with a steep power law, closer to the wave turbulence prediction than the Kolmogorov one like in the latter case. It is believed that the averaging effect may be a source of difficulty to detect the transition towards wave turbulence in natural plasmas. For the first time, the formation of filaments is reported within current and vorticity sheets in strongly magnetized flows which modifies our classical picture of dissipative sheets in conductive flows.

P. Cardin
University of Grenoble (LGIT, France)

Experimental measurements of Alfven waves in a liquid metal
P. Cardin, T. Alboussiere, F. Plunian, A. Ribeiro(*) and D. Schmitt
LGIT, *LIMSI

Alfven waves are generated by a coil at the bottom on a cylindrical cavity (h=10cm, R=5cm) filled of Gallinstan. Strong axial magnetic fields from 1 to 13T are imposed by an electromagnet from GHMFL. With coils at different heigths, we clearly see the propagation of the Alfven wave, its attenuation and its reflection at the top of the cylinder. A preliminary comparison with a numerical modelisation of the experiment (A. Ribeiro) show a good agreement.

F. Cattaneo
University of Chicago/ANL (USA)

MRI driven turbulence and dynamo action

The magneto-rotational instability (MRI) provides a rationale for the anomalous transport of angular momentum in accretion discs.

I will illustrate some of the properties of the ensuing turbulence and in particular its ability to regenerate magnetic fields (dynamo action). I will show some results in which dynamo action can definitely be established and discuss the challenges, both theoretical and computational, to the extension of these results to the limit of small magnetic Prandtl number.

A. Courvoisier
University of Leeds (UK)

The influence of spatial coherence on mean induction and diffusion (poster)

We calculate the mean magnetic induction and the mean scalar diffusivity for two families of motions in which the degree of spatial coherence can be systematically varied. We show that the mean induction is substantially reduced in less spatially correlated flows whereas the mean diffusivity is not significantly altered.

E. Dormy
ENS Paris/ IPGP (France).

Time scales separation for dynamo action

Joint work with D. Gérard-Varet.

The study of dynamo action in astrophysical objects classically involves two time scales: the slow diffusive one and the fast advective one. We investigate the possibility of field amplification on an intermediate time scale associated with time-dependent modulations of the flow. We consider a simple steady configuration for which dynamo action is not realised. We study the effect of time-dependent perturbations of the flow. We show that some vanishing low frequency perturbations can yield exponential growth of the magnetic field on the typical time scale of oscillation. The dynamo mechanism relies here on a parametric instability associated with transient amplification by shear flows.

C. Forest
University of Wisconsin, Madison

Numerical Simulations of a Plasma Dynamo and MRI Experiment

In this talk, I will describe a proposed plasma experiment that can investigate both self-exciting dynamos and magnetorotational instabilities. The differences between plasma-specific phenomena and pure MHD (incompressible liquid metal experiments) will be reviewed. Then, results from numerical simulations establishing the feasibility of the experiment will be described. Finally, initial results from an experimental prototype experiment may be presented.

N. Gagnière
LGIT Grenoble (France)

The modified Taylor's state with turbulent Ekman layers and comparison with experimental results. (poster)

We consider a magnetostrophic regime with a rotating spherical Couette flow in a dipolar magnetic field. Under the influence of rotation, motions are organized in geostrophic cylinders, and the torque applied by Lorentz forces on these ones is balanced by the viscous friction in Ekman layers in the upper and lower boundaries. This modified Taylor's state has been studied by Kleeorin et al. (1997) in the laminar regime, but to explain experimental results, we adapt this approach taking into account the turbulent friction in Ekman layers.

From this torque balance, we deduce the radial profile of angular velocity. Ultrasonic Doppler measurements are in very good agreement with the shape of the profile : we observe a region of nearly solid body rotation in the central part of the spherical shell; and when we go towards the outer sphere, the shear increases resulting in a decrease of the angular velocity to reach zero on the outer boundary. When the forcing increases, turbulent Ekman friction increases and the thickness of the layer is enhanced. Moreover, we can also obtain the total dissipated power and study the ratio between viscous and ohmic dissipations.

P. Garaud
U. California Santa Cruz (USA).

The solar tachocline

The tachocline is a thin shear layer located near the base of the solar convection zone, operating the dynamical and thermal transition between the convective region and the radiative zone below. I will present some new results on the tachocline dynamics and compare models with observations.

L. Garcia de Andrade
U. Estado do Rio de janeiro

Stretching dynamos in compact curved Riemannian spaces (poster)

ABC flows and filaments stretching are considered in Riemannian compact 3D spaces. Examples of dynamo action and discussion of anti-dynamo theorems in filaments are given.

A. Giesecke
FZD Germany

Kinematic dynamos in cylindrical geometry

In order to understand the results of recent dynamo experiments, the behavior of kinematic dynamos in cylindrical geometries is analyzed. Simulations are performed applying a hybrid finite volume/boundary element method that allows a stringent treatment of insulating boundary conditions. A suitable prescribed velocity field, either analytic or – more realistic -- from measurement data from water experiments, leads to dynamo action, and a strong influence of boundary conditions and additional (stagnant) fluid layers around the active domain is observed. An additional source term for dynamo action exists in case of a spatially varying conductivity distribution. A very simple set-up -- serving as a proof of concept -- is given by a steady axial flow in an infinite cylinder with inhomogeneous container walls. Such a configuration is sufficient for dynamo action, however, the critical Reynolds number might be too large for the realization in a simple laboratory-sized experiment. Similar effects appear in case of permeability inhomogeneities, where increased gradients might also lead to a significant reduction of the critical Reynolds number.

C. Gissinger
ENS Paris (France)

Modelisation and simulations of dynamo experiments

We present results of 3D direct numerical simulations for different flow geometries used to try to generate experimental dynamos. In the case of the VKS experiment, we show how boundaries with a high magnetic permeability lead to a significant decrease of the critical magnetic Reynolds number, thus allowing the observation of dynamo action.

We also understand the mechanism leading to experimentally observed geometries of the magnetic field without using any ad hoc mean field equation.

In the case of the geometry of the Madison experiment, we show different mechanisms by which Cowling theorem can be by-passed, thus leading to a mean magnetic field with a strong axial dipolar component instead of the predicted equatorial dipole. Finally, we propose modifications of the Madison experiment that could lead to the observation of a dynamo effect.

Numerical simulation of galactic dynamo (poster)

We present a simple model of galactic dynamo based on the large scale differential rotation and the small scale helical fluctuations due to supernovae explosions. We report for the first time direct numerical simulations of the full galactic dynamo using a direct, unparameterized, global approach. While the actual supernovae characteristics can only be approached, we show that the numerical simulations yield magnetic structures which are close both to observational constraints and to the parameterized mean field approach. In particular, the quadrupolar symmetry and the spiraling properties are observed. Moreover, our simulations show that the gravitational inflow plays an essential role to increase the magnetic field growth. This observation appears to confirm the important role of the galactic fountain in the galactic dynamo mechanism.

L. Goudard

IPGP/ENS

Dynamo-Region Geometry Controlling Stars and Planets Magnetic Behavior

The geo and solar magnetic fields have long been thought to be very different objects both in terms of spatial structure and temporal behavior. The recently discovered field structure of a fully convective star is more reminiscent of planetary magnetic fields than the Sun's magnetic field, despite the fact that the physical and chemical properties of these objects clearly differ. This observation suggests that a simple controlling parameter could be responsible for these different behaviors. We report here the results of three-dimensional simulations which show that varying the aspect ratio of the active dynamo region can yield sharp transition from Earth-like steady dynamos to Sun-like dynamo waves.

C. Guervilly

LGIT Grenoble (France)

Numerical simulations of spherical Couette dynamos

We'd like to present DNS of spherical Couette dynamos. Special attention will be given on the effect of global rotation which can reduce the onset by a factor 10. Implications for future experiments will be discussed.

W. Herreman
IRPHE University of Marseille

Kinematic dynamo of inertial waves

Inertial waves are natural oscillatory tridimensional perturbations in rapidly rotating flows. They can be driven to high amplitudes by an external oscillatory forcing such as precession, or by a parametric instability such as in the elliptical instability. Inertial waves were observed in a MHD-flow (Gans, 1971, JFM ; Kelley et al., 2008, GAFD) and could be responsable of dynamo action. For traveling waves, a constructive alpha-effect was identified (Moffatt, 1970, JFM), but it does not apply to confined inertial wave flows. Yet, recent numerical work demonstrated that precession driven MHD flows can sustain magnetic fields (Tilgner, 2005, POF ; Wu & Roberts, 2008, GAFD). This motivates us to study more precisely how inertial waves can exhibit dynamo action. Using a numerical code in cylindrical geometry, we find that standing inertial waves can generate a kinematic dynamo. We show that the dynamo-action results from a second order interaction of the diffusive eigenmodes of the magnetic field with the inertial wave. Scaling laws are obtained, which allows us to to apply the results to flows of geophysical interest.

H. Homann

Observatoire de la Cote D'Azur

Clustering of passive impurities in MHD-turbulence

Results on clustering of passive heavy particles in incompressible MHD-turbulence by means of direct numerical simulations will be presented. Impurities tend to form preferential concentrations in the vicinity of coherent structures such as current- and vortex-sheets. They have density distributions far from Poissonian type. Comparisons to the statistics of heavy particles in hydrodynamic turbulence will be drawn.

D. Hughes

University of Leeds (UK)

Dynamos driven by Shear and Turbulent Convection

Rotating turbulent convection, although helical, does not act as an effective large-scale dynamo -- contrary to naive expectations from mean field theory. I shall look at the influence of an imposed large-scale shear on turbulent convective dynamo action in two regimes --- in the absence and presence of small-scale dynamo action --- to investigate the possible generation of a large-scale field.

A. Jackson

ETH Zurich

Simple 3-D Taylor State Models of Earth's Core.
with P Livermore & G Ierley

We adopt the idea of magnetostrophic balance in the core. It is well known that in this balance, when inertia, nonlinear advection and viscosity are ignored, the magnetic field must obey a morphological constraint known as Taylor's constraint.
The structure of the Taylor constraint can be derived when the magnetic field is represented in a finite expansion based on spherical harmonics and polynomials in radius that satisfy the required regularity at the origin.
Here we report on calculations that solve a lower bound problem, or equivalently an optimisation problem, to minimise the Ohmic dissipation in the core subject to given boundary values of the poloidal field supplied by a recent geomagnetic field model, and subject to various other constraints. Such a problem is a completely well-posed bounding problem with a unique lower bound, though finding the solution is challenging when Taylor's constraint is imposed, due to the nature of the many nonlinear constraints present.
Values for the lower bound were given by Jackson & Livermore (2008) when a variety of additional constraints were added, including those arising from the idea that nutational data indicate values for the rms field strengths at the CMB and ICB. Here we present the results for some low-order models which satisfy Taylor's constraint in addition.
These models include the presence of a toroidal magnetic field, which plays a role in the annihilation of the Taylor torques (azimuthal components of the vertically-averaged Lorentz torque on cylinders coaxial with the rotation axis).

D. Jault
LGIT Grenoble
Quasi-geostrophic modelling of the geomagnetic secular variation

I will present/discuss theoretical arguments that allow to propose a quasi-geostrophic (QG) model for the fast - non diffusive - variations of the Earth's magnetic field. The QG model can be coupled to equations for the evolution of axial averages of quadratic products of the magnetic field in the Earth's core volume. Using the magnetic field at the core surface as a tracer, a variational data assimilation approach can be used and constraints on the state of the Earth's core can be obtained. The specific case of Alfvén waves consisting of geostrophic motions nicely illustrates these ideas.

C. Jones

University of Leeds

Zonal flows and Jupiter's dynamo

The atmospheres of the giant planets have fast zonal flows of order 100 m/s. These jet-flows have a banded structure, eastward and westward flows alternating as latitude varies. It has been proposed that these flows extend in to the deep interior of the giant planets, where they meet the dynamo region, controlled by magnetic field. Evidence suggests that there the flows are several orders of magnitude slower. The variable electrical conductivity transition region where this velocity adjustment occurs is analysed.

W. Kuang

NASA Goddard Space Flight Center

Variation of the Dynamo domain and sudden termination of Mars Dynamo

Numerical simulation showed that the Mars dynamo could be subcritical towards the end of it history: as the Rayleigh number (measuring the driving force of the dynamo) decreases from the strong-field dynamo domain, the numerical Mars magnetic field remains comparable in magnitude. It vanishes suddenly when the Rayleigh number is lower than a critical value. However, the Mars dynamo will not be reactivated until the Rayleigh number increases to a value much higher than the critical point for the termination of the dynamo. To better understand the termination of the Mars dynamo, it is important to understand first the variation of the dynamo region in which the emf offsets the Joule dissipation. Our initial analysis shows that the dynamo region is often around the tangent cylinder (a co-axial cylindrical surface across the outer core tangent to the inner core boundary at the equator) and extended outward significantly. As the Rayleigh number decreases, the dimension of the region is reduced, and tends to fluctuate stronger in time. These two combined may suggest that there is probably a critical dimension, below which the dynamo region can no longer be sustained by core convection.

K. Kuzanyan
University of Leeds (UK)
Compressible convection in rapidly rotating spherical atmospheres of giant planets

We are systematically studying compressible convection in rapidly rotating spherical shells using anelastic approximation meaning to understand large-scale flows in the atmospheres of giant planets. The onset of convection has been studied within the linear theory where we have carried out an asymptotic analysis for the limit of fast rotation (Ekman number goes down to 0) supporting our numerical studies. We found that convection onsets near the outer sphere for compressible case, but near the tangent cylinder for Boussinesq. For low values of Prandtl number we have found more compressible effects which cause greater spiraling of the convection pattern. All these properties are inherited by further development of convection from the onset towards the highly nonlinear case. The on-going massive numerical simulations show the crucial role of the boundary conditions in forming multiple jets inside the tangent cylinder. This phenomenon is not very robust for the case of no-slip velocity condition at the inner boundary. We are able to confine the parameter range for the shell aspect ratio, Ekman number, and density scale height which are most favorable for formation of multiple jets. Our compressible anelastic model is challenged by the opportunity to produce a pattern of alternate jets inside the tangent cylinder and, particularly, strong vortices near the polar regions which are observed in giant planets by means of recent space missions.

J. Léorat

CNRS et Observatoire de Paris-Meudon

MHD problems in heterogeneous domains with conducting and permeability jumps

Implementation of exact magnetic boundary conditions are a well known challenge for MHD simulations. We are currently developing a nonlinear hybrid code (spectral Fourier and finite elements) convenient for any axisymmetric heterogeneous domains. We intend to present results obtained on various MHD problems such as the finite Taylor-Couette dynamo and the keplerian flat disk

N. Leprovost
University of Sheffield

Dynamo quenching due to Shear

We provide a theory of dynamo (alpha effect) and momentum transport in three-dimensional magnetohydrodynamics in presence of a large-scale shear flow. For the first time, we show that the kinematic alpha effect is reduced by the shear with a scaling alpha=alpha_0 S^{-5/3}. This can provide some limitations on the efficiency of an alpha-Omega dynamo. We also consider the suppression of alpha effect by strong magnetic fields and show that dynamo can saturate well below equipartition (with the large-scale flow) with different scalings depending on the relative strength of shear and magnetic field. Recently, this quenching of the alpha effect has been confirmed in a numerical experiment [http://arxiv.org/abs/0806.1608].

S. Mathis
EA/DSM/IRFU/Service d'Astrophysique

Magneto-Gravito-Inertial waves in strongly stratified stellar interiors

Stellar radiation zones are stable strongly stratified rotating magnetic regions. The buoyancy force, the Coriolis acceleration and the Lorentz force are thus ruling the internal waves dynamics, such waves being thus equivalent to the MAC waves studied in Geophysics. In this work, we examine the behavior of these waves in stellar interiors and we show how the approximations assumed in the non-magnetic case (for gravito-inertial waves) can be generalized. The associated angular momentum transport, which strongly impacts on the evolution of stars over secular times-scales, is then studied and discussed.

W. Mouhali
Observatoire de Paris-Meudon

Cyclonic vortex regime in a precessing cylinder flow (poster)

In the perspective to make a dynamo experiment, we study the precessing forcing flow in a cylinder (ATER experiment). The effect of precession can be seen as a Kelvin waves modes forcing (linearized solution) with a laminar flow when the precession rate (control parameter) is far the critical violent-breakdown to turbulence transition. However, the PIV studies show a “non linear” regime (from an boundary layer instability) of cyclonic and quasi stationnary vortices in differential rotation. The central symetrybreaking caused by this regime is encouraging for obtaining a dynamo regime.

V. Morin
ENS lyon

Numerical investigation of the dynamo bifurcation in Geodynamo Models

We investigate the dynamo bifurcation --i.e. the onset of dynamo action-- in numerical models relevant to the Earth's core. As usual in such models, controlling parameters are very remote from relevant geophysical values, sometimes by factors in excess of a million. We show how the nature of the dynamo bifurcation happens to be very sensitive to the parameters regime. We report supercritical bifurcations, subcritical bifurcations and isola. We describe how this behavior depends on the relevant parameters. Finally, we show that two distinct dynamo branches with different energies can be described for a given set of parameters. While viscous effects are not negligeable in simulations, this could be related to the weak and strong field branches which have been proposed in the context of the Geodynamo.

A. Newton
University of Sheffield (UK)

Numerical Investigation into sheared MHD turbulence

Shear flows and magnetic fields are ubiquitous in nature, playing a crucial role in turbulent transport. Here, we present the first numerical results of the suppression of magnetic diffusion by a shear flow in 2D MHD turbulence. For a very strong magnetic field, a new scaling regime of magnetic diffusion quenching by magnetic fields is found, with a stronger dependence on magnetic field strength compared to the previous result [1]. Furthermore, we show the first numerical evidence of enhanced transport due to the interaction between shear flow and magnetic field via resonances,which weakens the magnetic diffusion quenching. Similar results are also presented for momentum transport. [1] F. Cattaneo & S.I. Vainshtein, Astrophys. J. Lett. 376. L21 (1991)

C. Nore
LIMSI-CNRS, Universite Paris Sud 11 (France)

Impact of impellers in the VKS2 dynamo experiment

In the VKS2 successful dynamo experiment of September 2006, the magnetic field that was observed showed a strong axisymmetric component, implying that non axisymmetric components of the flow field were acting. By modeling the induction effect of the spiraling flow between the blades of the impellers in a kinematic dynamo code, we find that the axisymmetric magnetic mode is excited and becomes dominant in the vicinity of the dynamo threshold. The control parameters are the magnetic Reynolds number of the mean flow, the coefficient measuring the induction effect, alpha, and the type of boundary conditions. We conjecture that the dynamo action achieved in this experiment may not be related to the turbulence in the bulk of the flow, but rather to the alpha effect induced by the impellers.

C. Normand
IPhT, CEA-Saclay (France)

Modal versus energetic stability of cylindrical kinematic dynamos. (poster)

The kinematic dynamo problem is solved in a cylindrical geometry using a Galerkin approach. Depending on the choice of the weighting functions the method either leads to a modal or to an energetic stability analysis. The energetic approach is used to derive lower bounds on the magnetic Reynolds number Rm, following the results of Backus for the spherical case. Using a variational principle more accurate values of Rm are obtained in the case of helical flows. It is found that the azimuthal modes m=0 and m=1 exhibit transient energy growth for very close values of Rm.

L. Petitdemange
ENS-LRA (France)

Magnetostrophic MRI in the Earth's Outer Core

We show that a simple, modified version of the Magnetorotational Instability (MRI) can develop in the outer liquid core of the Earth, in the presence of a background shear. It requires either thermal wind, or a primary instability, such as convection, to drive a weak differential rotation within the core. The force balance in the Earth's core is very unlike classical astrophysical applications of the MRI (such as gaseous disks around stars). Here, the weak differential rotation in the Earth core yields an instability by its constructive interaction with the planet's much larger rotation rate. The resulting destabilizing mechanism is just strong enough to counteract stabilizing resistive effects, and produce growth on geophysically interesting timescales. We give a simple physical explanation of the instability, and show that it relies on a force balance appropriate to the Earth's core, known as magnetostrophic balance.

F. Petrelis
ENS Paris (France)

Excitability in the vicinity of a saddle-node bifurcation: a mechanism for reversals

The magnetic field generated by dynamo action is known to display either periodic oscillations (in the Sun) or random reversals (in the Earth). I present a study of the dynamics generated by the competition between two magnetic modes.

A new scenario is identified that explains both the regimes of random reversals and of periodic oscillations. For the regime of random reversals, the qualitative features of this scenario will be presented: existence of reversals and excursions, shape of reversals and excursions, existence of long durations without reversals. The predictions of the model are compared with the characteristics of reversals derived from the paleomagnetic records as well as from the laboratory experiment (Von Karman Sodium experiment

N. Plihon
ENS Lyon (France)

The synthetic Bullard-Von Karman dynamo

We have built a versatile fluid experiment in liquid gallium. It implements a synthetic dynamo cycle which mimics an alpha-omega dynamo and for which the flow turbulence is fully included and has a leading role. The omega process is obtained from motion of the liquid gallium in a Von-Karman flow (by counter-rotation of impellers in a cylindrical vessel). The alpha process is provided by current circulation in coils.

We show that the flow turbulence statistics control the dynamics of the synthetic dynamo (on/off intermittency, reversals...)

F. Plunian
LGIT Grenoble (France)

Oscillating Ponomarenko dynamo in the highly conducting limit

We consider dynamo action in smooth helical flows in cylindrical geometry, otherwise known as Ponomarenko dynamos, with periodic time-dependence. An asymptotic framework is developed that gives growth rates and frequencies in the highly conducting limit of large magnetic Reynolds number, when modes tend to be localized on resonant stream surfaces. This theory is validated by means of numerical simulations.

Y. Ponty
Observatoire de la Cote d'azur, CNRS (France).

Dynamo simulations inside Pseudo-Penalisation Boundaries

We consider a penalisation method to modelised boundaries inside a periodic simulations. Inside cube, a cylinder or a sphere geometries the fluid is constraint, living the magnetic fields in the periodic box, we are seeking the different dynamo modes.

M. Proctor

DAMTP, University of Cambridge (UK)

"Interactions Of An Unstable Shear Flow With A Convectively Unstable Region" with, L.J.Silvers (Cambridge) and P.J.Bushby (Newcastle)

This talk is concerned with the interaction of a convectively unstable region with an unstable shear layer in the presence of an imposed vertical magnetic field. It is shown the interaction of such a layer with a convectively unstable region depends on the imposed field strength. In particular, for strong fields, the hydrodynamic unstability is suppressed and a magnetic buoyancy instability of interchange type is excited. This instability causes tube like structures, that span the entire length of the box, to rise with a drastic impact on the convection, which is forced to deviate greatly from that found in the purely hydrodynamic case.

A. Pouquet

NCAR, Boulder (USA)

Waves and turbulence in MHD

We study decaying magnetohydrodynamics (MHD) turbulence stemming from the dynamics of the Taylor-Green flow generalized recently to MHD (IMTG), with equal viscosity and magnetic resistivity up to equivalent grid resolutions of 2048^3 points. A pseudo-spectral code is used in which the symmetries of the IMTG flow have been implemented, allowing for sizable savings in both computer time and usage of memory at a given Reynolds number. The flow is non-helical and at initial time, the kinetic and magnetic energies are taken to be equal and concentrated in the large scales.

We find that the global temporal evolution is accelerated, compared to the corresponding neutral fluid case. We also observe a sizable interval of time during which the flow. We study decaying magnetohydrodynamics (MHD) turbulence stemming from the dynamics of the Taylor-Green flow generalized recently to MHD (IMTG), with equal viscosity and magnetic resistivity up to equivalent grid resolutions of 2048^3 points. a pseudo-spectral code is used in which the symmetries of the IMTG flow have been implemented, allowing for sizable savings in both computer time and usage of memory at a given Reynolds number. The flow is non-helical and at initial time, the kinetic and magnetic energies are is semi-stationary with quasi-constant total dissipation, time during which statistical properties are analyzed after averaging. An anisotropic investigation of energy spectra confirms the findings of a non-symmetric fully helical flow with a tendency toward anisotropic weak turbulence and with a complex spatial structure of current and vorticity sheets.

Co-authors: M.E. Brachet (ENS, Paris), E. Lee (NCAR), P. Mininni (Buenos Aires and NCAR) and D. Rosenberg (NCAR)

K.H. Radler
Astrophysical Institute Potsdam (Germany)

Mean-field effects in the Galloway-Proctor flow

The mean electromotive force in a Galloway--Proctor flow of a electrically conducting fluid is investigated. This flow shows a two-dimensional pattern and is helical. The pattern wobbles in its plane. Mainly the case of a harmonic time dependence, that is, of a circular motion of the flow pattern, already to a certain extent studied by Courvoisier, Hughes and Tobias (2006), is considered. An analytic theory of the alpha effect and related effects in this flow is developed within the second-order correlation approximation and

a corresponding fourth-order approximation. In the validity range of these approximations there is an alpha effect but no gamma (or pumping) effect. Numerical results obtained with the test-field method, which are independent of this approximation, confirm the results for alpha and show that gamma is in general nonzero. Both alpha and gamma show a remarkably complex dependency on the magnetic Reynolds number and other parameters that define the flow, that is, amplitude and frequency of the wobbling motion. Some results for the magnetic

diffusivity are given, too. It may take negative values. Finally a result for alpha in a randomly time-dependent flow without the aforementioned circular motion is presented. This flow is a particularly appropriate model for studying the alpha effect and related effects in flows that are statistically isotropic in a plane.

Authors: K-.H. R\"adler and A. Brandenburg

R.L. Ricca
U. Milano-Bicocca (italia)

On the groundstate energy of knotted magnetic flux tubes

In this paper we present new results on the magnetic relaxation of magnetic flux tubes embedded in a perfectly conducting incompressible fluid to minimum energy magnetostatic groundstates. The magnetic field, decomposed in toroidal and poloidal components, is confined to a single, possibly knotted flux tube. By adopting a local orthogonal, curvilinear coordinate system we calculate the magnetic energy functional following the approach of Chui & Moffatt [1]. Their results, obtained in a non-orthogonal coordinate system, are corrected and replaced by exact analytical expressions. The groundstate energy of tight magnetic knots is then investigated. The energy spectrum of torus knots is directly computed as function of the internal twist and compared with Chui & Moffatt's one. For generic knot types, simple relationships between minimum energy states and knot complexity are found in terms of crossing number. These results may find applications in the energetics of astrophysical flows and provide further grounds to establish a mathematical foundation for the classification of physical knots and links based on a one-to-one correspondence between energy and topology [2].

[1] Chui, A.Y.K. & Moffatt, H.K. (1995) The energy and helicity of knotted magnetic flux tubes. Proc. R. Soc. Lond. A 451, 609-629.
[2] Ricca, R.L. (2008) Topology bounds energy of knots and links. Proc. R. Soc. A 464, 293-300.

A simple kinematical model for Stretch-Twist-Fold dynamo (poster)

Preliminary results on a simple kinematical model of the Stretch-Twist-Fold (STF) mechanism, originally proposed by Vainshtein & Zel'dovich [1] for fast dynamo, are presented. The evolution is prescribed by an appropriate set of equations [2, 3], that govern the simultaneous stretching, writhing and coiling of a magnetic flux tube by a diffeomorphism of the initial circular configuration. Simple estimates based on minimized magnetic energy show that exponential growth of the magnetic field is indeed possible.

[1] Vainshtein, S.I. & Zel'dovich, Ya. B. (1972) Sov. Phys. Usp. 15, 159.
[2] Maggioni, F. & Ricca, R.L. (2006) Writhing and coiling of closed filaments. Proc. R. Soc. A 462, 3151.
[3] Ricca, R.L. & Maggioni, F. (2008) A new stretch-twist-fold model for fast dynamo. In PAMM-ICIAM'07, Zürich, in press.

K. Richardson
University of Cambridge (UK)

Effects of Fluctuations on Alpha Omega Dynamo Models: Spatial and Temporal Variation

We investigate the role of a fluctuating α-effect in $\alpha\Omega$ dynamo models. We extend the calculations of Proctor (2007) to include spatial variation of the fluctuations, and find that there can be a mechanism for magnetic field generation, even when the mean α is zero, provided the spatiotemporal spectrum of the fluctuations has an appropriate form. We investigate dynamo action in a 1-D model when the new term arising from the fluctuations is non-zero, and we determine the region of parameter space where oscillating solutions occur.

P. Roberts
University of California, Los Angeles, UCLA (USA)

Numerical simulation of a spherical dynamo excited by a flow of von Karman type

In a celebrated experiment last year, Monchaux et al. (2007) created a self-excited dynamo in a cylindrical container of liquid sodium by a turbulent flow created by counter-rotating impellers at the plane ends of the container. A strange feature of the experiment was its failure to generate magnetic field when the impellers were made of stainless steel; success required the impellers to be made of soft iron with a magnetic permeability of about 100. The results reported here were generated by numerical simulations of an idealization of the experiment. The container is a deep spherical shell and the impellers are replaced by a prescribed differential zonal motion of the outer surface, the northern and southern hemispheres turning about the symmetry axis in opposite senses. Two main cases are considered. In one the surface of the fluid is an electrical insulator; in the other it is a thin shell of conducting material surrounded by insulator. In the latter case, the shell was represented by the thin wall boundary condition, as used in MHD duct flow; see, for example, Section 3.2.2 of Muller and Buhler (2001). Examples are presented in which, for the same surface motion, an amplified field is generated in the second case but not in the first.

* Monchaux, R., Berhanu, M., Bourgoin, M., Moulin, M., Odier, Ph., Pinton, J.-F., Volk, R., Fauve, S., Mordant, N. Petrelis, F., Chiffaudel, A., Deviaud, F., Dubrulle, B., Gasquet, C., Marie. L. and Ravelet, F., 2007, Generation of magnetic field by dynamo action in a turbulent flow of liquid sodium, Phys. Rev.Letts., 98, 044502.
* Muller, U. and Buhler L., 2001, Magnetofluiddynamics in Channels and Containers. Springer: Berlin, Heidelberg.

I.Rogachevskii

Ben-Gurion of the University Negev (Israel)

Nonhelical mean-field dynamos in sheared turbulence

We study mechanisms of nonhelical large-scale dynamos (shear-current dynamo and effect of homogeneous kinetic helicity fluctuations with zero mean) in a homogeneous turbulence with large-scale shear. We have found that the shear-current dynamo can act even in random flows with small Reynolds numbers. However, in this case mean-field dynamo requires small magnetic Prandtl numbers. For turbulent flows with large Reynolds numbers shear-current dynamo occurs for arbitrary magnetic Prandtl numbers. This dynamo effect represents a very generic mechanism for generating large-scale magnetic fields in a broad class of astrophysical turbulent systems with large-scale shear. On the other hand, mean-field dynamo due to homogeneous kinetic helicity fluctuations alone in a sheared turbulence is not realistic for a broad class of astrophysical systems because it requires a very specific random forcing of kinetic helicity fluctuations that contains, e.g., low-frequency oscilla
tions. These results have been obtained using the second order correlation approximation (or first-order smoothing), the spectral tau-approximation and the renormalization approach.

T. Rogers

University of Arizona (USA)

The interaction of Internal Gravity Waves and Magnetic Fields

Both magnetic fields and gravity waves have been identified as processes which could redistribute angular momentum in the solar radiative interior. While both surely exist in the radiative interior, studies have studied the processes independently. In this talk I will discuss the interaction of internal gravity waves and magnetic fields in the solar radiative interior and the angular momentum redistribution which ensues.

G. Ruediger

AIP (Germany)

MRI and Tayler instability in the laboratory

We study experimentally the Taylor-Couette flow of a liquid metal in the presence of externally imposed axial and azimuthal magnetic fields. For increasingly large azimuthal fields a wave-like disturbance arises, traveling along the axis of the cylinders. The field strengths and rotation rates at which they arise in the experiment PROMISE are broadly consistent with theoretical predictions of such a traveling wave magnetorotational instability.

The stability of TC flows for almost uniform toroidal magnetic fields is also considered. For high enough critical Hartmann numbers the toroidal field is unstable. Rigid rotation stabilizes the magnetic (kink-)instability while slow but differential rotation acts destabilizing. The axial current which drives the instability is reduced by the electromotive force induced by the instability itself. Numerical simulations are presented to probe this effect as a possibility to measure the turbulent magnetic diffusivity in the laboratory. If the cylinders are rotating then also the eddy viscosity can be measured. Nonlinear simulations lead to a turbulent magnetic Prandtl number of 2.1 for a molecular magnetic Prandtl number of 0.01. The trend goes to higher values for smaller Pm.

D. Schmitt

LGIT University of Grenoble (France)

Magneto-inertial waves in a rotating fluid sphere

The existence of waves (inertial, torsional, Alfvén-type, magneto-inertial...) in the liquid outer core of the Earth is still an open question. They could be related to the secular variation of the Earth's magnetic field, as a manifestation of the dynamo process. More widely, they are expected to occur in astrophysical objects such as stars or accretion discs. Recently, waves have been observed in two spherical Couette experiments using sodium as conducting fluid and in the presence of an imposed magnetic field. In the Maryland experiment, they have been interpreted as being inertial waves excited by a strong differential rotation [1]. In the Grenoble experiment, several types of waves have been identified, all retrograde compared to the mean fluid rotation, and they exhibit specific dispersion relations [2]. A numerical code has been developed to describe these magneto-inertial waves, in which the background velocity and magnetic field have an arbitrary axisymmetric configuration. It is presently in a validation phase, and preliminary results will be presented.

A. Shukurov

School of Mathematics and Statistics, Newcastle University, U.K.

Flux rope dynamos

We suggest a new model of the fluctuation dynamo, where magnetic field reconnection is included directly rather than modelled via the induction equation. This results in more efficient dynamo action and significantly enhanced energy dissipation rate.

L. Silvers

University of Cambridge (UK).

Long-term nonlinear behaviour of the magnetorotational instability in a localized model of an accretion disc (poster)

For more than a decade, the so-called shearing-box model has been used to study the fundamental local dynamics of accretion discs. This approach has proved to be very useful because it allows high-resolution and long-term studies to be carried out, studies that would not be possible for a global disc.

Localized disc studies have largely focused on examining the rate of enhanced transport of angular momentum, essentially a sum of the Reynolds and Maxwell stresses. The dominant radial-azimuthal component of this stress tensor is, in the classic Shakura-Sunyaev model, expressed as a constant α times the pressure. Previous studies have estimated α based on a modest number of orbital times. Here we use much longer baselines, and perform a cumulative average for α. Great care must be exercised when trying to extract numerical α values from simulations: dissipation scales, computational box aspect ratio, and even numerical algorithms can all affect the result. This study suggests that estimating α becomes more, not less, difficult as computational power increases.

D. Sokoloff

Moscow State University

Magnetic field in fluctuating ABC flow

Standard dynamo model for large-scale magnetic field generation in celestial bodies presume turbulent or convective flows to be considered locally as statistically homogeneous and isotropic however mirror-asymmetric random fields. Basing on ABC-flow which is considered as a classical example of dynamical chaos, we clarify to what extent we can avoid this presumption. We demonstrate that this flow can not excite a large-scale magnetic field even if the coefficients A,B and C are considered as random processes.

A.M. Soward

University of Exeter (UK).

Shear-layers in magnetohydrodynamic spherical Couette flow with conducting walls

We consider the steady axisymmetric motion of an electrically conducting fluid contained within a spherical shell and permeated by a centred axial dipole magnetic field, which is strong as measured by the Hartmann number M. Slow motion is driven by rotating the inner boundary relative to a thin stationary outer boundary. For M>>1, viscous effects are only important in Hartmann boundary layers adjacent to the inner and outer boundaries and a free shear-layer on the magnetic field line tangent to the outer boundary at the equatorial plane of symmetry. The inner boundary is perfectly conducting, while we measure the ability to leak electric current into the thin solid outer boundary by its relative conductance epsilon. The nature of the flow is sensitive to the value of epsilon, because electric current leakage weakens the strength of the Hartmann layer. Super-rotation occurs in the free shear-layer. Asymptotic solutions are presented, which predicts that the maximum rotation rate in the shear-layer increases in concert with the electrical conductivity (proportional to epsilon) of the outer boundary. The main emphasis of the study is on the perfectly conducting limit epsilon>>1 for which the maximum rotation rate is the order of the square root of M. The asymptotic solutions are compared with the numerical solution of the full partial differential equations governing the system.

S. Tobias

University of Leeds (UK).

How do dynamos saturate ?

In this talk I shall discuss the possible mechanisms for dynamo saturation. I shall discuss some numerical experiments that utilise models of convective dynamos and MHD shell models and argue that none of the simpler mechanisms that have been proposed for dynamo saturation are correct and that the dynamo saturation process can be even more subtle than even the most pessimistic dynamo theorist expected. I shall also discuss the implications for mean field theory in the nonlinear regime.

G. Verhille
ENS Lyon (France)

Velocity Measurement in a Screw Flow

Several processes were proposed to explain induction of the magnetic field in a turbulent velocity field. In order to to study the α-effect and the β-effect, a rotating torus filled with liquid metal at room temperature was built in Perm. Turbulent and decaying motion is imparted to the liquid when rapidly stopping the torus. The mean velocity field has the right topological properties to study these effects.

Previous work in a similar flow showed that the α-effect was important shortly after braking. Recent studies by the Perm's group led to similar conclusions as for the β-effect that was observed only at the beginning of the braking.

In order to precisely measure toroidal and poloidal velocity fields, a velocity probe was inserted in the flow. I will present results on the turbulent flow dynamics obtained with the velocity probe, and link the flow features with previous studies on α and β effects.**T.**

T. Yousef
Imperial College (UK)

New results on dynamo action in sheared and rotating turbulence

We demonstrate, using forced MHD simulations, that non helical turbulence in the presence of linear shear can give rise to a mean field dynamo. For a range of shearing rates S, spanning approximately two orders of magnitude, the resulting magnetic field grows exponentially with a growth rate ~ S and a characteristic length scale, larger than the outer scales of the turbulence, ~ S-1/2. We find that this shear dynamo mechanism is quite robust. It can work, for example, for both rotating and non-rotating systems, and for flows that are sub- or super critical to the fluctuation dynamo. We identify the fluid motions responsible for magnetic field generation. The generic nature of the shear dynamo effect can makes it an attractive object of study for the generation of magnetic fields in a broad class of astrophysical systems.

T. Wood

University of cambridge (UK)

Magnetic confinement in the Solar Interior

It has long been known that the Sun's convection zone rotates differentially, whereas the radiation zone beneath rotates uniformly, and is separated from the convection zone by a thin shear layer known as the tachocline. We follow up the suggestion of Gough & McIntyre that the interior's uniform rotation can only be explained by the presence of a magnetic field, which must be prevented from diffusing into the convection zone near the poles by meridional circulations within the tachocline. We present a family of solutions for the field configuration in the polar regions, and describe the influence of helium diffusion on the magnetic confinement picture.