GdR Dynamo

Monday 7 June 2010

9h30-10h30	***INVITED*** *Andy Jackson* PRELIMINARY DESIGN OF THE ZÜRICH MHD EXPERIMENT (40+20)
10h30-11h00	*Break*
11h00-11h30	*Yannick Ponty* LARGE SCALE AND SMALL SCALE DYNAMOS (20+10)
11h30-12h00	*Yves Elskens* DYNAMO RAPIDE ET DIFFUSION DES PARTICULES DANS UN ECOULEMENT ABC STOCHASTIQUE : UNE PREUVE RAPIDE (20+10)
12h00-12h30	*Wietze Herreman* STOKES DRIFT DYNAMOS (20+10)
12h30-14h00	*Lunch*
14h00-15h00	***INVITED*** *Jean-François Donati* MAGNETIC FIELDS OF COOL STARS - THE MANY FACES OF DYNAMOS (40+20)
15h00-15h30	*Break*
15h30-16h00	*Nicolas Gillet* FAST TORSIONAL WAVES AND STRONG MAGNETIC FIELD WITHIN THE EARTH'S CORE (20+10)
16h00-16h30	*Florian Lhuillier* ON THE RANGE OF GEOMAGNETIC PREDICTABILITY: LINK WITH THE OHMIC DISSIPATION TIME (20+10)
16h30-17h00	*Basile Gallet* DYNAMICAL REGIMES OF MAGNETIC FIELD IN A SPHERICAL KINEMATIC DYNAMO MODEL: FROM FIELD REVERSALS TO HEMISPHERICAL DYNAMOS (20+10)
17h00-17h35	Présentation des posters (1 slide / 5 minutes) *Alexandros Alexakis, Elisabeth Canet, Céline Guervilly, Philippe Marti, Nicolas Plihon, Martin Schrinner.*
17h35-19h00	Posters

GdR Dynamo

Tuesday 8 June 2010

9h00-10h00	***INVITED*** *Sebastien Aumaitre* DÉVELOPPEMENTS RÉCENTS DE L'EXPÉRIENCE VKS (40+20)
10h00-10h30	*Break*
10h30-11h00	*Gauthier Verhille* ETUDE DES CONDITIONS AUX LIMITES DANS UN ÉCOULEMENT DE VON KARMAN (20+10)
11h00-11h30	*Caroline Nore* A FINITE ELEMENT APPROACH OF MHD PROBLEMS IN HETEROGENEOUS DOMAINS (20+10)
11h30-12h00	*Alban Sauret* LIBRATION AND TIDES DRIVEN FLOWS IN PLANETARY CORES (20+10)
12h00-12h30	*David Cebron* TIDES INDUCED MAGNETIC FIELD AND TIDES DRIVEN DYNAMOS (20+10)
12h30-13h00	*Maylis Landeau* EQUATORIALLY ANTISYMMETRIC CONVECTION AND HEMISPHERICAL MAGNETIC FIELD GENERATION IN ROTATING SPHERES; IMPLICATIONS FOR THE PAST MARTIAN DYNAMO (20+10)
13h00-14h30	*Lunch*
14h30-15h30	***INVITED*** *Denys Schmitt* DÉVELOPPEMENTS RÉCENTS DE L'EXPÉRIENCE DTS (40+20)
15h30-16h00	Conclusion

ABC DYNAMOS

Alexandros ALEXAKIS,
Laboratoire de physique statistique, Ecole normale supérieure.

I will present a numerical investigation of the dynamo instability over a the family of flows known as the ABC. The fasted growing mode is calculated for a moderate range of magnetic Reynolds numbers. It is shown that breaking some of the symmetries of the most commonly studied (A=1,B=1,C=1) ABC flow can increase significantly the growth rate.

DÉVELOPPEMENTS RÉCENTS DE L'EXPÉRIENCE VKS

Sebastien AUMAITRE, *GIT-SPEC CEA-Saclay.*

Si les régimes dynamiques du champ magnétique observés dans l'expérience VKS sont globalement bien compris, ce n'est paradoxalement pas le cas des mécanismes dynamo engendrant ce champ. Afin de mieux comprendre les processus d'amplification et l'influence des conditions de bord sur les mécanismes de l'instabilité, il a été réalisé une série d'expériences avec différentes conditions aux limites hydrodynamiques et électromagnétiques. Après un bref rappel des résultats obtenus dans la configuration initiale de référence, nous détaillerons les observations obtenues dans des configurations différentes afin de souligner celles prépondérantes dans le mécanisme dynamo de l'expérience VKS.

ESTIMATIONS DU CHAMP MAGNÉTIQUE À L'INTÉRIEUR DU NOYAU TERRESTRE

Elisabeth CANET *Institut of Geophysics, ETH Zurich, Suisse*,

joint work with Alexandre Fournier, Dominique Jault.

Les changements du champ magnétique terrestre sur une grande gamme d'échelles spatiales et temporelles reflètent les processus variés de la géodynamo. Nous étudions un modèle simplifié de la dynamique rapide du noyau, adapté à l'étude des variations rapides du champ magnétique variant des années aux siècles ; la variation séculaire.

Nous décrivons les procédés physiques en jeu aux échelles de temps de la variation séculaire avec un modèle quasi-géostrophique de la dynamique du noyau. L'hypothèse quasi-géostrophique du modèle est basée sur la prépondérance des forces de rotation par rapport aux forces magnétiques à ces échelles de temps. La partie axisymétrique correspond au formalisme d'ondes de torsion d'Alfvèn. La dynamique se place dans le plan équatorial, le champ de vitesse est décrit par une fonction courant non-zonale et le champ magnétique par un seul potentiel scalaire. À la frontière noyau-manteau, l'écoulement interagit avec le champ magnétique radial via la composante radiale de l'équation d'induction. Cette partie du modèle connecte la dynamique et les observations.

L'assimilation variationnelle de données permet d'interprèter la variation séculaire en terme de dynamique. Une fonction objectif est minimisée en calculant sa sensibilité par rapport aux variables de contrôle via l'intégration du modèle adjoint.

Nous développons les champs magnétique et de vitesse en une partie stationnaire et une partie, plus faible, dépendant du temps. Nous résolvons un problème inverse pour définir cet état de base stationnaire à partir d'observations indirectes du champ de vitesse à la frontière noyau-manteau, résultats d'inversions cinématiques qui utilisent aussi l'hypothèse quasi-géostrophique.

Le système d'équation qui définit l'état de base stationnaire se résume à un équilibre magnétostrophique, couplé avec un équilibre d'advection-diffusion du champ magnétique. Nous donnerons un aperçu de ce système et de ses possibles solutions. Ainsi que des résultats préliminaires d'inversion pour cet état de base.

TIDES INDUCED MAGNETIC FIELD AND TIDES DRIVEN DYNAMOS

David CEBRON, *IRPHE*,

joint work with Herreman Wietze, Le Bars Michael, Maubert Pierre, Le Gal Patrice.

Many celestial bodies (planets, stars, galaxies...) possess their own magnetic field, either by induction of an external field, or by a natural dynamo mechanism. Up to now, only two kinds of natural forcing have been identified as dynamo-capable: thermo-solutal convection [1], which is the standard mechanism generally applied to all planetary configurations even if it is not proved to be fully relevant, and precession [2]. Two other forcings have been proposed, which are the flow generated by librations of the celestial body, and the flow driven by the tidal instability [3]. This last forcing is still controversial from an energetic point of view, as well as the dynamo capabilities of such a flow, which is studied here and validated numerically for the first time.

The tidal instability takes place in planetary cores elliptically deformed by gravitational effects. It has been studied by our group for several years because of its relevance in geo- and astro-physical flows. So far, the MHD simulations of stellar or planetary dynamos have been performed in spherical or spheroidal geometries, which facilitate and accelerate the computations but also prevent any tidal instability. Because of the small amplitudes of tidal bulges, this approximation could be thought correct, but since the tidal instability comes from a parametric resonance, an infinitesimal deformation can lead to first order modifications of the flow. To study its MHD consequences, we develop the first numerical MHD simulations in a triaxial ellipsoid. Firstly, the interaction of the tidal instability with an imposed magnetic field has been theoretically, experimentally and numerically studied [4,5]. In particular, it is shown that a non-negligible component of Io's magnetic field comes from an induction process of Jupiter's field driven by the tidal instability [6]. Secondly, the interaction between a thermal field and the tidal instability has been numerically studied, which shows the relevance of this instability in the context of convective geophysical flows. The interaction of the elliptical instability with thermal effects reveals striking features such as the enhancement of the growth rate by a thermal stratification or the destruction of the Busse columns by the elliptical instability [7]. Finally, our numerical approach confirms the possibility of a tidal dynamo, which validates the instability as a possible source of magnetic field in stars and planets.

[1] Glatzmaier, G.A. \& Roberts, P.H, 1995. Nature 377, 203-209.
[2] Tilgner, A., 2005. Phys. Fluids 17, 034104.
[3] Kerswell, R.~R., 2002. Annual Review of Fluid Mechanics, 34, 83--113.
[4] Lacaze et al., 2006. Geophys. Astrophys. Fluid Dyn. 100, 299--317.
[5] Herreman, W., Cebron, D., Le~Diz\`es, S. Le~Gal, P., 2010. Elliptical instability in rotating cylinders: liquid metal experiments under imposed magnetic field. Submitted to J. Fluid Mech.
[6] Herreman, W., Le~Bars, M., Le~Gal, P., 2009. Phys. Fluids 21, 046602.
[7] Cebron et al., 2010. Tidal instability in a rotating and differentially heated ellipsoidal shell. Submitted to Geophys. J. Int.

MAGNETIC FIELDS OF COOL STARS - THE MANY FACES OF DYNAMOS

Jean-François DONATI, *LATT*.

Our observational knowledge of stellar magnetic fields has tremendously improved since GE Hale's detection of sunspot magnetic fields about a century ago. In particular, the last two decades provided new detections in classes of stars not yet known as magnetic, as well as information not previously accessible (eg surface maps of complex magnetic fields) thanks to the advent of new-generation high-efficiency instruments dedicated to stellar magnetometry.

After briefly reviewing the observational techniques and modelling tools underlying these new results, i will describe how magnetic fields are found to change with stellar parameters (eg mass, rotation rate) and with time (eg magnetic cycles), focussing in particular on cool stars with masses 0.1-1.5 Msun and their dynamo fields / differential rotation patterns.

I will finally outline some promising research directions (eg global dynamos of brown dwarfs, local dynamos from giant convective cells) and the future instruments needed to tackle this new challenge.

DYNAMO RAPIDE ET DIFFUSION DES PARTICULES DANS UN ECOULEMENT ABC STOCHASTIQUE : UNE PREUVE RAPIDE

Yves ELSKENS, ***UMR 6633, équipe turbulence plasma.***

Le calcul différentiel "rugueux" fournit une preuve directe qu'un écoulement ABC à paramètres browniens engendre une dynamo rapide, et que, de plus, N particules test diffusent indépendamment dans la limite des temps longs. La preuve souligne l'utilité de la description lagrangienne de l'écoulement et de l'évolution du champ. Elle permet de retrouver simplement des résultats connus en abrégeant significativement les calculs.

DYNAMICAL REGIMES OF MAGNETIC FIELD IN A SPHERICAL KINEMATIC DYNAMO MODEL: FROM FIELD REVERSALS TO HEMISPHERICAL DYNAMOS

Basile GALLET, ***LPS-ENS*****,**

joint work with F. Pétrélis.

It has been proposed recently that magnetic field reversals result from the coupling between two magnetic modes, one of dipolar symmetry and another one of quadrupolar symmetry. As far as planetary magnetic fields are concerned, this linear coupling occurs when the equatorial symmetry of the problem is broken by the flow. We performed analytical computations of $alpha^2$ spherical dynamos. The dipolar and quadrupolar modes are computed from the induction equation. When the alpha effect breaks the equatorial symmetry, these modes get coupled and exhibit either reversals or localization of the magnetic field in only one of the two hemispheres of the planet. The first regime corresponds to the Earth' magnetic field reversals, whereas the second one could describe Mars' magnetic field, which is sometimes claimed to have been localized in the southern hemisphere of the planet only. We will discuss these two different behaviors in the framework of low-dimensional dynamical systems.

FAST TORSIONAL WAVES AND STRONG MAGNETIC FIELD WITHIN THE EARTH'S CORE

Nicolas GILLET, ***LGIT*****,**

joint work with Dominique Jault, Elisabeth Canet et Alexandre Fournier.

The magnetic field inside the Earth's fluid and electrically conducting outer core cannot be directly probed. The root-mean squared (rms) intensity for the resolved part of the radial magnetic field at the Core-Mantle Boundary (CMB) is 0.3~mT, but further assumptions are needed to infer the strength of the field inside the core. Recent diagnostics obtained from numerical geodynamo models\cite{aubert09} show that the magnitude of the dipole field at the surface of a fluid dynamo is about ten times weaker than the rms field strength in its interior, which yields an intensity of the order of several mT within the Earth's core. However, a 60-year signal found in the variation in the length-of-day\cite{roberts07} (ΔLOD) has long been associated with magneto-hydrodynamic torsional waves carried by a much weaker internal field\cite{zatman97,buffett09}: according to these studies, the rms strength of the field in the cylindrical radial direction (calculated for all length scal es) is only 0.2~mT, a figure even smaller than the rms strength of the large scale (spherical harmonic degree $n\le13$) field visible at the CMB. Here we reconcile numerical geodynamo models with studies of geostrophic motions in the Earth's core relying on geomagnetic data. From an ensemble inversion of core flow models, we exhibit indeed a torsional wave recurring every 6 years, whose angular momentum accounts well for both the phase and the amplitude of the 6-year ΔLOD signal detected over the second half of the twentieth century\cite{abarca00}. It takes about 4 years for the wave to propagate throughout the fluid outer core: this travel-time translates into a slowness for Alfv\'en waves which corresponds to a rms field strength in the cylindrical radial direction of approximately 2~mT. Assuming isotropy, this yields a rms field strength of 4~mT inside the Earth's core.

QUASI-GEOSTROPHIC THERMAL CONVECTION IN A RAPIDLY ROTATING SPHERE

Céline GUERVILLY, *LGIT, Grenoble, UJF/CNRS*,

joint work with Philippe Cardin.

Using a combination of a quasi-geostrophic (QG) model for the velocity field and a classical spectral 3D code for the temperature field, we compute thermal convective motions in a rapidly rotating full sphere. The QG flow is computed in the equatorial plane, whereas the temperature field is calculated within the full sphere. The coupling terms are evaluated by interpolating onto the 2D (equatorial) and 3D coarse grids. Our hybrid approach allows us to compute simulations at low Ekman numbers, low Prandtl numbers and explore the strongly non-linear regime currently inaccessible with purely 3D codes. We pay particular attention to the zonal winds generated by non-linear interactions between the convection columns.

STOKES DRIFT DYNAMOS

Wietze HERREMAN, *LRA - ENS, France*,

joint work with Pierre Lesaffre.

In recent years, classical results of mean field dynamo theory have been under some attack. Mean field coefficients have been compared to results calculated from direct numerical simulations and quite often a strong disagreement has been observed in particular in the high conductivity limit. This suggests that modifications to mean field dynamo theory are necessary.

In the present work, we reconsider mean field dynamo theory in the limit of a highly conductive medium, without supposing a space scale separation between the growing magnetic field and the flow. Such approach generally leads to unpractical spatially dependent alpha and beta tensors, but through straightforward and exact manipulations, we show how these tensors can actually be reduced to a much simpler mean field effect than previously expected.

It turns out that the mean magnetic fields satisfy themselves an induction equation with an effective pumping flow that is recognized as the Stokes drift associated with the fluctuation flow. We remember that the Stokes drift is the mean Lagrangian velocity that is followed by tracer particles in the fluctuation flow and that it was originally introduced by Stokes (1847) to understand mean particle transport under gravity waves. Incidentally, the dynamo analysis produces an explicit formula for this flow that was previously unknown. The theory is successfully tested in an example where we realize a G.O. Roberts dynamo through well chosen fluctuation flows that have the G.O. Roberts flow as Stokes drift.

As a result, we propose a new and physically appealing explanation of mean field dynamo action in the high conductivity limit, that clearly differs from the classical idea that helicity plays a prominent role in the dynamo.

PRELIMINARY DESIGN OF THE ZÜRICH MHD EXPERIMENT

Andrew JACKSON, *ETH Zürich*,

joint work with Xing Wei, Kuan Li, Rainer Hollerbach.

We are in the planning stages of a new rotating MHD experiment, most likely using liquid sodium. We plan to drive the flow using Lorentz forces due to an injected current. An applied magnetic field acting with the injected current flow can create reasonably large flows.

We have performed some preliminary calculations for a DTS-like geometry with primarily radial current flow (quadrupole symmetry) in an axial dipole-symmetry magnetic field; we have also considered the case of dipole symmetry current flow and quadrupole fields.

The advantages, it seems, are the ability to easily change to different configurations of Lorentz force, and the wide dynamic range that is available. I will discuss the possible outcomes of the experiment.

EQUATORIALLY ANTISYMMETRIC CONVECTION AND HEMISPHERICAL MAGNETIC FIELD GENERATION IN ROTATING SPHERES; IMPLICATIONS FOR THE PAST MARTIAN DYNAMO

Maylis LANDEAU, *Dynamique des fluides géologiques, Institut de Physique du Globe de Paris* (landeau@ipgp.jussieu.fr),

joint work with Julien Aubert.

Rotationally dominated convection is typically organized into vortices aligned with the rotation axis. These columnar structures tend not to violate the Taylor-Proudman constraint which requires the velocity field to be invariant along the rotation axis. Here, we used numerical simulations to model thermal convection and dynamo effects driven by secular cooling in rotating full spheres. We focus on such processes because they have probably been widespread in the early solar system, particularly in Mars' core. We find a spontaneous hydrodynamic transition towards a flow regime characterized by the emergence of equatorially antisymmetric, axisymmetric (EAA) modes, in apparent conflict with the Taylor-Proudman constraint. We show that these EAA modes result from the combination of Ekman pumping and thermal winds. We obtain scaling laws for the regime boundaries and the amplitude of these modes. We show that the EAA regime can also induce hemispherical dynamos, with stronger magnetic field in one hemisphere. We discuss the possible implications of our results for the past Martian dynamo.

ON THE RANGE OF GEOMAGNETIC PREDICTABILITY: LINK WITH THE OHMIC DISSIPATION TIME

Florian LHUILLIER, *IPGP Géomagnétisme / Dynamique des Fluides Géologiques*,

joint work with Gauthier Hulot, Julien Aubert.

To constrain the temporal window in geomagnetic data assimilation, it is of interest to quantify the range of predictability of the geodynamo. This range of predictability is intrinsically limited by the non-linear nature of the governing equations, and can be evaluated thanks to the "dynamical method" designed by the meteorologists. This method involves the numerical integration of twin solutions originating from slightly different initial conditions, and then the study of the error growth.

From a systematic study of the sensitivity of numerical dynamos to various instabilities, we propose a physical mechanism to explain the amplification of the errors. Considering the equations of magnetohydrodynamics linearised about the reference state, we suggest that the equation of motion is responsible for the balance between the errors of the various physical quantities, whereas the equations of heat and induction control the rate of amplification through an advective process. More precisely, we suggest that the horizon of predictability is closely linked to the turbulence associated with the most diffusive field. We indeed find that the error-growth timescale is equal to smallest dissipation time. Estimating the ohmic dissipation time to be of the order of 40 yr for the Earth, we thus obtain a range of predictability of the order of 90 yr when assuming an initial error of 10%.

A FULLY SPECTRAL FULL SPHERE DYNAMO SIMULATION

Philippe MARTI, *ETH Zürich*,

joint work with Andy Jackson.

We will present a fully spectral full sphere dynamo simulation. A spherical harmonics expansion has been used for the horizontal part. The radial dependency has been expanded on a basis of Worland polynomials satisfying the regularity condition at the origin of the sphere. The developed code has been parallelised with the help of the MPI library. Some scalability and performance results will be presented.

A FINITE ELEMENT APPROACH OF MHD PROBLEMS IN HETEROGENEOUS DOMAINS

Caroline NORE, *LIMSI*,

joint work with J.-L. Guermond, J. Leorat, F. Luddens, A. Ribeiro.

The MHD equations in heterogeneous axisymmetric domains composed of conducting and nonconducting regions are solved by using a mixed Fourier/Lagrange finite element technique. Finite elements are used in the meridian plane and Fourier modes are used in the azimuthal direction. Parallelization is made with respect to the Fourier modes. Continuity conditions across interfaces between vacuum and conductor or between different conductors (like soft iron material and liquid sodium) are enforced using an interior penalty technique. The performance of the method is illustrated on kinematic dynamo configurations.

INDUCTION À FORT PARAMÈTRE D'INTERACTION

Nicolas PLIHON, *Laboratoire de Physique ENS Lyon*,

joint work with Gautier Verhille, Jean-François Pinton, Ruslan Khalilov, Peter Frick.

Nous présentons des résultats expérimentaux de mesures d'induction dans l'écoulement von-Karman Gallium (écoulement turbument de gallium liquide dans un cylindre, mis en mouvement par la rotation de deux disques coaxiaux) en présence d'un fort champ magnétique, transverse à l'axe du cylindre (pour des valeurs du paramètre d'interaction N pouvant atteindre 0,15).

L'analyse de l'induction et des grandeurs globales hydrodynamiques montre que les gradients de vitesse sont modifiés selon un scaling en N^{1/2} par la force de Laplace. Nous présenterons également l'effet de la force de Laplace sur la dynamique basse fréquence du champ de vitesse.

LARGE SCALE AND SMALL SCALE DYNAMOS

Yannick PONTY, *Observatoire de La Cote d'Azur*,

joint work with Franck Plunian.

Using the well-know G.O Robert velocity forcing, we are looking at the effect of velocity fluctuations on the large scale dynamo.We will present also how a small scale dynamo mode is appearing and affecting this alpha effect.

LIBRATION AND TIDES DRIVEN FLOWS IN PLANETARY CORES

Alban SAURET, *IRPHE*,

joint work with C. Morize, D. Cébron, P. Le Gal, S. Le Dizès & M. Le Bars.

As for any rotating fluid, planetary cores support oscillatory motions called "inertial waves", whose frequencies range between twice the spin frequency. Usually damped by viscosity, these waves can nevertheless be excited by various natural processes such as libration, precession and tides, providing that their azimutal period m and temporal frequency _ are in close agreement with those of the forcing. Once a mode is selected, its nonlinear self-interaction generates intense axisymmetric flows when associated to viscous boundary layers effects. Several experiments have reported visualizations of geostrophic flows in rotating containers driven by precession or libration. But only few quantitative measurements have been reported, based on dye tracing or laser Doppler velocimetry . Moreover, no general agreement seems to exist between analytical, experimental and numerical results. The purpose of the present work, which is based on a systematic experimental study, is thus to systematically quantify the amplitude of these geostrophic flows and to prove the universality of the underlying mechanism in studying the forcing by tides or by libration.

We show that the non-linear mechanism of zonal flow generation is indeed fully generic and that the induced geostrophic velocity systematically scales as the square value of the considered forcing. Such a mechanism could therefore take place almost generically in the liquid cores of planets, but also in the atmospheres of gas giants such as Jupiter, where it would constitute an additional source of zonal winds generation in complement to the already suggested convective and 2D turbulent models.

DÉVELOPPEMENTS RÉCENTS DE L'EXPÉRIENCE DTS

Denys SCHMITT, *LGIT, Grenoble*,

joint work with l'équipe Geodynamo.

Au cours de l'année écoulée, plusieurs innovations majeures concernant l'instrumentation ont été mises en oeuvre dans l'expérience DTS à Grenoble.

La première innovation concerne la mesure du champ magnétique à l'intérieur-même du fluide, mesure qui faisait défaut jusqu'à présent. Les capteurs correspondants sont positionnés le long d'un support fixé à l'intérieur d'un "doigt de gant", installé radialement dans le fluide. Les expériences réalisées à l'aide de ce dispositif ont fourni pour la première fois une mesure directe du champ magnétique toroidal à l'intérieur du sodium. Ce champ peut atteindre par endroits 50 mT, soit près de 20% du champ dipolaire maximal présent dans le fluide (pour une fréquence de rotation de la graine de 30 Hz). Par ailleurs, nous avons complété nos mesures de vitesse du fluide par vélocimétrie Doppler ultrasonore selon plusieurs configurations de tir qui nous permettent maintenant de couvrir une grande partie du volume intérieur. Nous avons ainsi accumulé suffisamment de résultats pour tenter une inversion des données. Un modèle de vitesse azimutale a pu étre reconstitué, et comparé à des résultats de calculs numériques. Il confirme l'existence de trois zones dans le fluide : une zone de super-rotation équatoriale près de la graine, une zone externe géostrophique près de l'équateur, et une zone intermédiaire où la vitesse angulaire est constante et où le nombre d'Elsasser est de l'ordre de 1. Enfin, les lois de variation du champ induit et de la puissance dissipée par rapport au forçage ont été déterminées ; des effets non linéaires sont perceptibles.

La seconde innovation concerne l'installation d'une série de capteurs magnétiques sur la surface extérieure de la sphère externe, afin d'obtenir une large couverture spatiale pour la mesure des trois composantes du champ magnétique. Ces capteurs sont fixés sur une bande souple, ce qui permet des mesures au plus près du sodium liquide. L'analyse des corrélations magnétiques entre les différents capteurs situés à différentes positions a permis d'obtenir de nombreux détails sur la géométrie et la symétrie des ondes MC (magnéto-Coriolis) observées lorsque seule la sphère interne est en rotation : variation avec la latitude, type de symétrie équatoriale. Une structure spectrale fine commence ainsi à émerger dans la dépendance fréquentielle des ondes. Ces résultats peuvent être comparés à des calculs numériques obtenus à l'aide d'un code récemment développé.

OSCILLATORY DYNAMOS AND THEIR INDUCTION MECHANISMS

Martin SCHRINNER, *LRA-ENS*.

We look at a number of oscillatory dynamo models resulting from direct numerical simulations. The computation of corresponding mean-field coefficients helps to identify relevant dynamo mechanisms. We also compare mean-field results with direct numerical simulations. The good agreement between both demonstrates again the reliability of the so-called test-field method (Schrinner et al. 2005, 2007), which has been used to determine the mean-field coefficients.

ETUDE DES CONDITIONS AUX LIMITES DANS UN ÉCOULEMENT DE VON KARMAN

Gauthier VERHILLE, *Laboratoire de Physique de l'ENS Lyon*,

joint work with Nicolas Plihon, Mickael Bourgoin, Philippe Odier, Jean-François Pinton.

En 2006, l'expérience VKS a permis d'observer l'instabilité dynamo dans un écoulement non contraint dit de von-Karman (écoulement créé par la rotation de deux disques coaxiaux dans un cylindre). Dans cette expérience, le seuil de l'instabilité n'a pu être franchi qu'en utilisant des disques en fer doux. Dans ces conditions, le mode excité est différent du mode dynamo prévu par les simulations numériques basées sur l'écoulement moyen.

Dans l'expérience von-Karman en gallium, nous avons étudié l'effet de la diffusivité magnétique des disques sur les mécanismes d'induction en faible champ magnétique appliqué. Cette étude nous a permis de montrer que certains mécanismes d'induction dépendent fortement de la diffusivité des disques.

A partir de ces observations, nous présentons une interprétation de la génération de la dynamo VKS.