International Conference *Euler's Equations: 250 Years On*
Program of Lectures and Discussions

(Dated: June 14, 2007)

Schedule of the meeting

Tuesday 19 June	*Wednesday 20 June*	*Thursday 21 June*	*Friday 22 June*
08:30-08:40 Opening remarks	08:30-09:20 O. Darrigol/U. Frisch	08:30-09:20 G. Eyink	08:30-09:20 F. Busse
08:40-09:10 E. Knobloch	09:20-09:50 M. Eckert	09:30-10:00 P. Constantin	09:30-10:00 Ph. Cardin
09:20-10:10 J. Gibbon	09:50-10:30 *Coffee break*	10:00-10:30 T. Hou	10:00-10:30 J.-F. Pinton
10:20-10:50 Y. Brenier	10:30-11:20 P. Perrier	10:30-11:00 *Coffee break*	10:30-11:00 *Coffee break*
10:50-11:20 *Coffee break*	11:20-12:30 Poster session II	11:00-11:30 K. Ohkitani	11:00-11:30 Discussion D
11:20-11:50 K. Sreenivasan		11:30-12:00 P. Monkewitz	11:30-12:30 Discussion C
12:00-12:30 C.F. Barenghi		12:00-12:30 G.J.F. van Heijst	
12:30-14:00 Lunch break	*12:30-14:00 Lunch break*	*12:30-14:00 Lunch break*	*12:30-14:00 Lunch break*
14:00-14:50 I. Procaccia	14:00-14:30 G. Gallavotti	14:00-14:50 M. Ghil	14:00-14:30 N. Mordant
14:50-15:20 L. Biferale	14:40-15:10 L. Saint Raymond	14:50-15:20 A. Nusser	14:30-15:00 J. Bec
15:30-16:00 V. Lebedev	15:10-15:40 H. Chen	15:30-16:00 R. Mohayaee	15:00-15:30 R. Shaw
16:00-16:30 *Coffee break*	15:50-16:20 S. Wu	16:00-16:30 Å. Nordlund	15:30-16:00 *Coffee break*
16:30-17:00 G. Falkovich	16:20-16:50 Y. Fukumoto	16:30-17:00 *Coffee break*	16:00-17:00 Discussion L
17:00-18:00 Poster session I	16:50-17:10 *Coffee break*	17:00-18:00 Discussion S	17:00-18:00 Discussion G
	17:10-17:40 Discussion H		
	17:40-18:10 Discussion K		

Time intervals indicated for lectures include 5 min discussion.

Poster session I: H. Aluie, M. Arnold, F. Bouchet, A. Bronzi, M. Bustamante, C. Cao, R. Chetrite, L. Chevillard, A. Guba, G. Krstulovic, P. Lee, D. Li, T. Matsumoto, A. Mazzucato, W. Pauls, F. Ramos, S.S. Ray, T. Sakajo, K. Turitsyn, A. Venaille, M. Wilczek, X. Yu.

Poster session II: G. Araya, M. Berhanu, M. Branicki, P. Burattini, L. Duchemin, V. Eliasson, F. Fedele, R. Hillerbrand, P. Krueger, G. Lavaux, M. Le Bars, D. Mitra/R. Pandit, A. Naso, E. Simonnet, K. Singh, J. Sznitman, B. Thomases, D. Vincenzi, R. Volk, M. Vucelja, T. Zemach.

Discussion H: *Historical matters*, moderated by R. Narasimha.

Discussion K: *Computing high-Reynolds number flow: is kinetic theory useful?*, moderated by U. Frisch, R. Pandit.

Discussion S: *Singularities: what do we care?*, moderated by C. Bardos and E. Titi.

Discussion D: *Dynamos*, moderated by H.K. Moffatt and R. Moreau.

Discussion C: *Climate issues*, moderated by R. Hillerbrand and R. Moreau.

Discussion L: *Theoretical and numerical aspects of Lagrangian methods in turbulence*, moderated by G. Falkovich and J.-F. Pinton.

Discussion G: general discussion, moderated by E. Bodenschatz and A. Sobolevskiĭ.

For details on social events, including the banquet, see the last page.

Abstracts

***C.F. Barenghi**: Superfluid turbulence* This lecture is concerned with superfluids: liquid helium, atomic Bose-Einstein condensates and neutron stars. Superfluids are remarkable because they have zero viscosity. This property makes them Nature's best examples of textbooks' Euler perfect fluid. What makes superfluids even more remarkable is that quantum mechanics constrains the rotational motion to thin vortex filaments of fixed circulation and fixed core radius. This is unlike what happens in ordinary classical fluids, whose eddies can be of any size and strength. Since the nonlinear interaction is the same, superfluid turbulence can be thought as the ultimate simplification of classical turbulence. In this lecture I shall review recent experimental and theoretical results, highlighting the similarities and the differences between superfluid turbulence and classical turbulence.

***J. Bec**: Preferential concentration of inertial particles in turbulent flows* Dust, droplets and other finite-size impurities suspended in incompressible turbulent flows are commonly encountered in many natural phenomena and industrial processes. The most salient feature of such suspensions is the presence of strong inhomogeneities in the spatial distribution of particles. This phenomenon, dubbed preferential concentration, can affect the probability to find particles close to each other and thus have influence on their possibility to collide or to have biological, chemical and gravitational interactions. The aim of this lecture is to present an overview of the recent numerical and analytical developments made in the statistical characterization of such preferential concentrations.

L. Biferale: *Anisotropy in turbulent flows* We review the problem of anisotropy and its effects on the statistical properties of turbulent flows at high Reynolds numbers. We discuss the problem of how to disentangle in a systematic way isotropic from anisotropic fluctuations in the analysis of experimental and numerical data. We show that in such a way one can: (i) better assess the problem of universality of isotropic small scale fluctuations; (ii) reveal the presence of intermittency also in the anisotropic components; (iii) understand the slow recovery of isotropy at high Reynolds numbers observed in the experiments. We discuss also some puzzling numerical results about the scaling of longitudinal and transverse velocity fluctuations in isotropic turbulence.

Y. Brenier: *Geometric and variational features of the Euler equations* Following V.I. Arnold, we know that the motion of an inviscid incompressible fluid moving in a domain D follows a geodesic curve along the group of volume preserving diffeomorphisms for the metric induced by L^2. We show how the concept of generalized flows can help to understand the geometry of this group.

F. Busse: *Euler equations in geophysics and astrophysics* Euler equations used in geophysics and astrophysics typically include the Coriolis force. This property extends the range for applications of inviscid descriptions of flows since dissipative processes are often confined to thin Ekman layers. Features such as geostrophic flows, Rossby waves, inertial oscillations and thermal winds are induced by the Coriolis force. The modifications of these basic flows by effects of buoyancy and viscous friction permit the solution of numerous problems through perturbation techniques. The non-uniqueness of vorticity distributions may sometimes cause difficulties. Examples from convection in rotating spheres to flows in precessing cavities will be discussed. Finally the problem of the absence of turbulence in Taylor-Couette configurations in the range $-Re_E \leq Re \leq \tau + Re_E^2/4\tau$ (with $\tau \geq Re_E/2$) of Reynolds numbers Re (which includes Keplerian flows) will be addressed. Here $Re_E = 2\sqrt{1708}$ denotes the energy Reynolds number for the small gap limit, and the rotation rate $\tau = 2\Omega d^2/\nu$ is made dimensionless with the gap width d and the kinematic viscosity ν.

Ph. Cardin: *Dynamics and dynamos in planetary cores* The Coriolis force associated to the planetary rotation strongly influences the dynamics of the liquid metal central core of terrestrial planets. Developped thermal convection generates turbulent quasi-geostrophic flows which are able to start a self induced magnetic field. I will report on numerical and experimental models which illustrate the dynamics and dynamos in planetary cores.

H. Chen: *Lattice Boltzmann modeling, fundamentals and its applications for industrial flows* There have been nearly two decades since formation of the first lattice Boltzmann model. By now its physics and mathematic underpinning is on a much solid theoretical ground. Here the speaker is going to describe some fundamental theory of how to construct n-th order accurate lattice Boltzmann models for Navier-Stokes as well as beyond the linear non-equilibrium regime. Then the speaker is going to outline some of the key advantages associated with this method for computational fluid dynamics, and present some its recent applications for real industrial flows.

P. Constantin: *The blow up problem* I will discuss the blow up problem for 3D Euler equations from an analytic point of view.

O. Darrigol/U. Frisch: *From Newton's mechanics to Euler's equations* The Euler equations of hydrodynamics, which appeared in their present form in the 1750s, did not emerge in the middle of a desert. We shall see in particular how the Bernoullis contributed much to the transmutation of hydrostatics into hydrodynamics, how d'Alembert was the first to describe fluid motion using partial differential equations and a general principle linking statics and dynamics, and how Euler developed the modern concept of internal pressure field which allowed him to apply Newton's second law to infinitesimal elements of the fluid.

M. Eckert: *Water-art problems at Sans-souci — Euler's involvement in practical hydrodynamics on the eve of ideal flow theory* Frederick the Great blamed Euler for the failure of fountains at his summer palace Sans-souci. However, what is regarded as an example for the proverbial gap between theory and practice, is based on dubious evidence. In this paper I review Euler's involvement with pipe-flow problems for the Sans-souci water-art project. Contrary to the widespread slander, Euler's ability to cope with practical challenges was remarkable. The Sans-souci fountains did not fail because Euler was unable to apply hydrodynamical theory to practice, but because the King ignored his advice and employed incompetent practitioners. The hydrodynamics of the Sans-souci problem also deserves some interest because it happened on the eve of the formulation of the general equations of motion for ideal fluids. Although it seems paradoxical: the birth of ideal flow theory was deeply rooted in Euler's involvement with real flow problems.

G. Eyink: *Dissipative anomalies in singular Euler flows* Among the more fascinating—and perhaps unexpected—applications of the Euler equations is high-Reynolds-number turbulence. Experimental and theoretical investigations before World War II (Hugh Dryden, Geoffrey Taylor) suggested that energy dissipation in turbulent flow governed by the incompressible Navier-Stokes equation in many circumstances does not vanish in the limit of zero viscosity, or infinite Reynolds number. Lars Onsager (1945, 1949) observed that inviscid Euler equations may not conserve energy if the velocity field is sufficiently singular (Hoelder exponent $\leq 1/3$). Onsager used this exact result to predict (independently of Kolmogorov) the $-5/3$ energy spectrum in turbulent flow and suggested that the inertial-range energy cascade is described by singular solutions of the Euler equations. We present a simple explanation of Onsager's result, in terms of conservation properties of "coarse-grained" fluid equations for a continuous range of length-scales. The same considerations apply not only to energy, but also to other inviscid conservation laws, such as helicity in three space dimensions and enstrophy in two, or the conservation of circulations in any dimension. Onsager's point of view continues to suggest new properties of turbulent flow that can be tested by experiment and simulation. Despite many mathematical advances, however, there is still no physically satisfactory proof of existence of such dissipative Euler solutions, nor of their uniqueness and regularity. A solution of this outstanding problem could shed great light on turbulent flow dynamics and, possibly, other problems where singular Euler solutions may arise (e.g. cosmology).

G. Falkovich: *Conformal invariance and 2D turbulence* I shall review remarkable data on the statistics of vorticity isolines in 2d turbulence described by the Euler equation and related models. The data suggest that the isolines belong to the class of random curves called Schramm–Loewner Evolution. The statistics is conformally invariant. I shall briefly discuss direct relations between isolines in turbulence and cluster boundaries in critical phenomena. In particular, nodal lines of vorticity seem to be equivalent to critical percolation line. At the end, possible integrability of 2d Euler equation is discussed.

Y. Fukumoto: *Kinematic variational principle for motion of vortex rings* Vortex rings are prominent coherent structures in a diversity of fluid flows. I will show how topological ideas work to derive a theoretical upper bound on translation speed of a vortex ring. According to Kelvin-Benjamin's principle, a steady distribution of vorticity, relative to a moving frame, is realized as the state that maximizes the total kinetic energy, under the constraint of constant hydrodynamic impulse, with respect to variations preserving the vorticity-field topology. Combined with an asymptotic solution of the Euler equations for a family of vortex rings, we can skip the detailed solution for the flow field to obtain the translation velocity of a vortex ring valid to third order in a small parameter, the ratio of the core radius to the ring radius. Including small viscosity, Saffman's velocity formula of a viscous vortex ring is extended to third order, which gives an improved upper bound on the translation speed. Similarity of this principle is found with Rasetti-Regge's theory for three-dimensional motion of a vortex filament.

G. Gallavotti: *Equivalent equations in fluids and possible applications* Reversible equations for fluids are conjectured to be equivalent to the NS equations in a sense analogous to the equivalence between ensembles in equilibrium statistical mechanics. Tests and applications.

M. Ghil: *Fluid mechanics and climate dynamics: observations, simulations and (maybe) predictions* The scientific problems posed by Earth's fluid envelopes—its atmosphere, oceans, snow and ice—are central to major socio-economic and political concerns of the 21st century. It is natural, therefore, that a certain impatience should prevail in attempting to solve these problems. In this lecture, I'll review some of the collective efforts at assessing and, in a way, predicting climate change. Next, I'll illustrate the problems associated with the fluid envelopes within the climate system, by studying oceanic variability and its interaction with the atmosphere and sea ice. Finally, I'll try to outline a way of assessing, and possibly reducing, the uncertainties associated with climate prediction on the time scale of decades-to-centuries.

J. Gibbon: *The three-dimensional Euler fluid equations: where do we stand?* Despite their deceptive simplicity, the three-dimensional Euler fluid equations remain one of the most puzzling sets of equations in mathematical physics. While it has long been suspected that they develop a singularity in finite time, only limited rigorous results exist (such as the BKM theorem) and numerical evidence is contradictory. I will survey some of the results in this area but confine myself to remarks on the incompressible case. I will then move on to considering the motion of fluid particles governed by the Euler equations as an example of particle dynamics in a Lagrangian flow. Hamilton's quaternions are a unifying theme in this area as they are now widely used in the aero/astro and computer animation industries to understand the motion of rapidly moving objects undergoing three-axis rotations. Thus, other problems closely related to the Euler fluid equations, such as ideal MHD, barotropic compressible Euler and mixing can all be considered together.

G.J.F. van Heijst: *Two-dimensional turbulence on a bounded domain — the role of angular momentum* In contrast to its counterpart in the 3D world, turbulence in 2D is characterized by an inverse energy cascade. The presence of this inverse cascade in 2D turbulence is visible in the so-called self-organization of such flows: larger vortices and structures are observed to emerge from initially random flow fields.

The lecture will address the evolution of 2D turbulent flows on a finite domain with no-slip walls. The organized state consists of a large, domain-filling cell whose motion can be considered as inviscid and hence governed by the Euler equation. Results of both laboratory experiments in rotating/stratified fluids and numerical simulations, however, reveal the crucial role played by the unsteady boundary layers: the domain boundaries act as important sources of large-amplitude vorticity filaments that may influence the motion in the interior. Attention will be given to global flow quantities like the kinetic energy, the enstrophy, and the total angular momentum. In the case of forced 2D turbulence, the latter quantity may show a remarkable flip-flopping behaviour, associated with a collapse of the organized flow state followed by its re-organisation.

T. Hou: *Blow-up or no blow-up? The interplay between theory and numerics* Whether the 3D incompressible Euler equations can develop a finite time singularity from smooth initial data has been an outstanding open problem. Recent studies indicate that the local geometric regularity of vortex filaments can lead to dynamic depletion of vortex stretching. Guided by the local non-blow-up theory, we have performed large scale computations of the 3D Euler equations on some of the most promising blow-up candidates. Our results show that there is tremendous dynamic depletion of vortex stretching. The local geometric regularity of vortex filaments and the anisotropic solution structure play an important role in depleting the nonlearity dynamically and thus preventing a finite time blow-up.

E. Knobloch: *Euler, the historical perspective* The lecture will give a survey of Leonhard Euler's life and scientific interests with a special emphasis on his sojourn in Berlin (1741-1766). The second part of this lecture will deal with Euler's less known contributions to mathematical astronomy that is to celestial mechanics. Euler (not Lagrange) found the first solution of a simplified case of the restricted three body problem and the first particular solution of the three body problem (the collinear case).

V. Lebedev: *Anomalous scaling of passive scalar advected by turbulent flow* Correlation functions of the passive scalar advected by a turbulent flow are known to possess an anomalous scaling related to their pumping length. The anomalous scaling is the most conspicuous manifestation of the intermittency characteristic of turbulence. Anomalous behavior of the passive scalar correlation functions can be examined in the framework of the Kraichnan model where the turbulent velocity is assumed to be short correlated in time and to possess Gaussian statistics. Closed equations for the correlation functions obtained in the framework of the model enable to relate the anomalous behavior to zero modes of the operators controlling the equations. Anomalous exponents can be explicitly calculated for different limit cases.

R. Mohayaee: *The Monge-Ampere-Kantorovich approach to reconstruction in cosmology* Reconstructing the density fluctuations in the early Universe that evolved into the distribution of galaxies we see today is a challenge to modern cosmology. An accurate reconstruction allows us to test cosmological models and put tighter constraints on cosmological parameters. Several reconstruction techniques have been proposed, but they all suffer from lack of uniqueness. Here we show that within a reasonable approximation reconstruction can be reduced to a well-determined problem of optimization, and present a specific algorithm that provides excellent agreement when tested against data from N-body simulations.

P. Monkewitz, with F. Noca and E. Robert: *The Euler number — Technological challenges of cavitation* The Euler number is essentially the ratio of the typical static pressure minus the vapor pressure and the typical dynamic pressure in a given flow. It therefore characterizes the propensity of the flow to cavitate, i.e. to form vapor bubbles. The technological importance of the phenomenon is shown on two examples—The abrasion of a solid by micron size particles (as for instance in a "wire saw") and the dynamics of laser generated cavitation bubbles in a liquid jet.

N. Mordant: *Lagrangian measurements in turbulent flows* Most measurements in turbulent flows are of Eulerian nature and often consist in measuring quantities (like the velocity field) in space at a given time. Lagrangian measurements deal with fluid particles trajectories: quantities are measured along the path of one single particle. This approach may seem more natural for some issues like emission and dispersion of a passive scalar but it is rather difficult to implement in experiments as particles have to be tracked with both a high spatial and temporal resolution. Only few Lagrangian experiments have been reported so far and some of them will be presented in this lecture.

Å. Nordlund: *Solar hydrodynamics* Solar hydrodynamics is one of the cases where numerical simulations of Eulerian dynamics have produced some of the most precise results. The dominant scale of convective motion near the solar surface produces the characteristic "granulation" radiation intensity pattern. The corresponding velocity field broadens spectral lines significantly, and the convective correlation of velocity and temperature causes spectral lines to be asymmetric and blue shifted. The observed widths, shifts, and asymmetries of solar spectral lines constitute a set of fingerprints that are well matched by high resolution numerical models, provided a realistic equation of state is used and the radiative losses at the surface are adequately modeled. Models and observations of larger scale motions reveal a spectrum of horizontal velocities that is approximately linear in horizontal wavenumber.

A. Nusser: *Eulerian and Lagrangian reconstruction method of cosmological velocity and density fields* Given the current distribution of matter in a cosmological background, the corresponding velocity field and the initial conditions can be reconstructed assuming tiny primordial fluctuations. After a short outline of dynamics in an expanding background, several classes of reconstruction methods will be described. The focus will be on the Euler-Zel'dovich equation and the least action principle based methods.

K. Ohkitani: *A geometrical study of 3D incompressible Euler flows with Clebsch potentials* We consider a special class of flows which have Clebsch potentials to explore possibility of blow up of the incompressible 3D Euler equations. This is perhaps geometrically the simplest, but nevertheless nontrivial vortex. After briefly reviewing what Clebsch has done, we introduce a criterion for geometric non-degeneracy, which should be satisfied for a possible blowup. Some preliminary results of numerical simulations will be presented. We will consider two kinds of initial conditions: (1) a simple choice of Clebsch potentials, and (2) Kida's high symmetric flow. For (1), we test the above-mentioned criterion for the early stage evolution. For (2), we derive the expressions for initial Clebsch potentials and observe their evolution.

J.-F. Pinton: *Experimental dynamo and dynamics* Several experiments have aimed at producing dynamo action in the laboratory. Landmarks are the solid rotor experiment of Lowes and Wilkinson (1963), the fluid dynamos in the Riga and Karlsruhe experiments (2000). I will discuss issues related to dynamo generation from turbulent or organized flows, and describe the results recently obtained in the VKS (von Kármán Sodium) experiment. A highly turbulent flow of sodium is set into motion inside a cylinder by the counter-rotation of propellers. A statistically steady, self-sustained dynamo is generated when the propellers are in exact counter-rotation above a critical rate. When one propeller rotates faster than the other, global rotation is imparted to the fluid, as in astrophysical objects. The magnetic field exhibits a variety of dynamical regimes, some of which very similar to the reversal of the Earth magnetic field.

P. Perrier*: Euler equations from the birth of CFD to present codes for multiphysics and complex geometry in aerospace and ground transportation engineering* The birth of Computational Fluid Dynamics appeared really with the Euler equations in the beginning of seventies with finite difference multi-physics numerical simulations of flow fields in hypersonic flow in the simple geometry of an axi-symmetric blunt body in competition with other analytical, empirical or numerical methods; however extension to more complex geometries let appear soon a lot of problems that required more than twenty years to be solved or only identified; parts was specific to an equation containing some drawbacks when put in discrete stable algorithms; the increase in speed of super-computers helped then to test in international workshops and validate versus experiments many promising new solvers. A survey of the improvements in numerical methods over years shows a parallel increase in engineering applications; particularly the discovery of some very interesting properties of the tridimensional Euler codes in the tracking of vortical flows has opened the way to predict the drag of blunt bodies, like cars, trucks or trains. However if the coupling with boundary layers on the body and with turbulent dissipation in wakes is necessary for better simulation it requires specific care; applications in aero-acoustics and in combustion continue to be in development and for the long years where speed of computers will not allow significant complexity of the geometries of vehicles to be tested.

I. Procaccia*: The state of the art in hydrodynamic turbulence: Past successes and future challenges* In this talk I will attempt to summarize briefly the greatest achievements in turbulence research over the decades, and what are the remaining central challenges for future research, both from the point of view of theory and of experiments.

L. Saint Raymond*: From Boltzmann's kinetic theory to Euler's equations* The incompressible Euler equations are obtained as a weak asymptotics of the Boltzmann equation in the fast relaxation limit (the Knudsen number Kn goes to zero), when both the Mach number Ma (defined as the ratio between the bulk velocity and the speed of sound) and the inverse Reynolds number Kn/Ma (which measures the viscosity of the fluid) go to zero.

The entropy method used here consists in deriving some stability inequality which allows to compare the sequence of solutions to the scaled Boltzmann equation with its expected limit (provided it is sufficiently smooth), and thus leads to some strong convergence result.

One of the main points to be understood is how to take into account the corrections to the weak limit, i.e. the contributions converging weakly but not strongly to 0 such as the initial layer or the acoustic waves.

R. Shaw*: Fluid dynamics of clouds: Turbulence, coalescence, and Euler's celebrated sum* Atmospheric clouds, a crucial piece of the climate change problem, are almost iconic as visualizations of turbulence. Some of the many aspects of turbulence interacting with cloud particles and radiation fields will be reviewed: from advection-diffusion, to inertial clustering, to stochastic coalescence. A toy model of stochastic rain formation provides an unanticipated application of Euler's celebrated solution to the "Basel problem," and this will provide a context for discussing the emerging recognition of the dominant role of fluctuations in cloud processes.

K. Sreenivasan*: Huge Reynolds numbers in small apparatus* Flows possessing kinematic and geometric similarities are also dynamically similar if the appropriate dimensionless parameters are matched. The most important dimensionless parameter for many flows is the Reynolds number; for thermal convection, it is the Rayleigh number. For practical purposes as well as fundamental understanding, one needs to study flows at very high values of these dimensionless parameters. This task is accomplished best by using helium as the working fluid. Examples of how the properties of helium-4 can be used to advantage will be discussed by citing results from recent studies. These examples will correspond to both the normal and superfluid states of helium.

S. Wu*: Recent progress in mathematical analysis of vortex sheets* We consider the motion of the interface separating two domains of the same fluid that moves with different velocities along the tangential direction of the interface. The evolution of the interface (the vortex sheet) is governed by the Birkhoff–Rott equations. We investigate the specific nature of the vortex sheet motion, in particular after the singularity formation; and consider the question of the weakest possible assumptions such that the Birkhoff–Rott equation makes sense. This leads us to introduce chord-arc curves to this problem. We present three results. The first can be stated as the following: Assume that the Birkhoff–Rott equation has a solution in a weak sense and that the vortex strength is bounded away from 0 and infinity. Moreover, assume that the solution gives rise to a vortex sheet curve that is chord-arc. Then the curve is automatically smooth, in fact analytic, for fixed time. The second and third results demonstrate that the Birkhoff–Rott equation can be solved if and only if ONLY half the initial data is given.

SOCIAL EVENTS

The **conference banquet** is taking place on Wednesday 20 June, at Centre Paul Langevin at 20:00. Everybody is invited, including accompanying persons (provided that we know about them). In case you or your accompanying person is not able to attend the banquet, please let Andrei Sobolevskii know this in advance (Tuesday evening at the latest).

For aperitif, a typical French cocktail *kir* (white wine + blackberry liquor) will be served. Non-alcoholic beverages will be available on request. At the banquet itself, a fine Bordeaux wine *Châteu Peybonhomme* will be served (1 bottle per 4 persons; additional bottles will be available from the restaurant at 12 Euro apiece).

The menu of the banquet follows. We feel that most of you will be offended if we provide a translation of this beautiful French document. Enjoy!

Menu du banquet

Aperitif : kir

Asperges et son nid de saumon fumé

Feuilleté de gambas et sa fondue de poireaux

Noix de veau vénitienne

Fagot haricots verts - Flan de Potiron

Méli melo de salade

Assiette de fromages

Délice de poire et son coulis de caramel

Vin : Château Peybonhomme (Bordeaux)

On Thursday 21 June, there will be an after-dinner presentation **Snow and avalanches: natural hasard, beauty and complexity** (in English) by Mr. Alain Duclos, a certified mountain guide (*guide de haute montagne*). Hopefully we will avoid having a real-scale demonstration...