Brief summary of the research interests of

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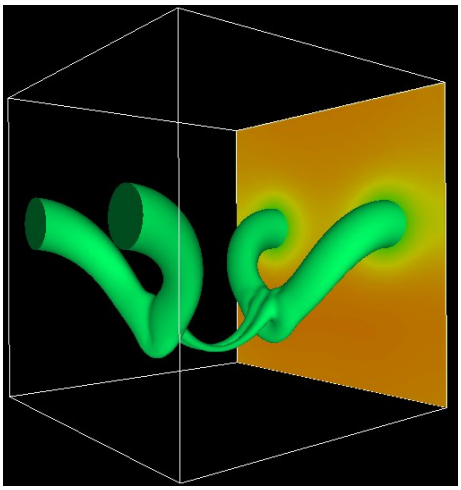

FIG. 1 – Reconnection of two vortices displayed through Iso-pressure surface.

My research activity is focused on modelling fundamental mechanisms mainly in fluid dynamics but also in more general nonlinear systems.

I do this through the use of **analytical** and **numerical** tools. More precisely, the main problems I am interested in, belong to one of the following areas

(a) **Vortex Dynamics**,

(b) **Hydrodynamic stability of open flows**,

(c) **Non-linear extended dynamical Systems such as coupled map lattices**.

(a) Turbulence is a major question of fundamental and practical interest. The action of coherent structures such as vortices which are observed in turbulent flows, are clearly central in this topic and comprehending the dynamics of these filaments is primordial. The first theme is directed towards understanding the evolution of a single or several interacting vortices. For my present investigations, this means studying vortex fusion in two-dimensional geometries, or reconnection in three-dimension (figure 1) as well as vortex creation by shear layer instabilities or else their destruction by other instabilities. For instance, figure 2 shows the evolution of a vortex subjected to a swirling jet instability. I will study in the near future the effect of density stratification on geophysical vortices (see the school i am organizing on this topic http ://corto.to.isac.cnr.it/aosta/).

A general discussion on these topics can be found in the **review article** *"Of vortices and vortical layers : an overview"* that can be downloaded from my web site.

Here is a list of subjects in which a work could be proposed :

- *Modelling the reconnection of vortices.*
- *Modelling the fusion of two-dimensional vortex.*
- *Studying the stability of vortices when stratification is present.*

(b) The second theme is directed towards the study of linear stability and transition of **boundary layers, jets or wakes dynamics**. In this context, I have studied the role and pertinence of notions such as convective/absolute instabilities, nonlinear finite amplitude states, non normal modes. I am presently

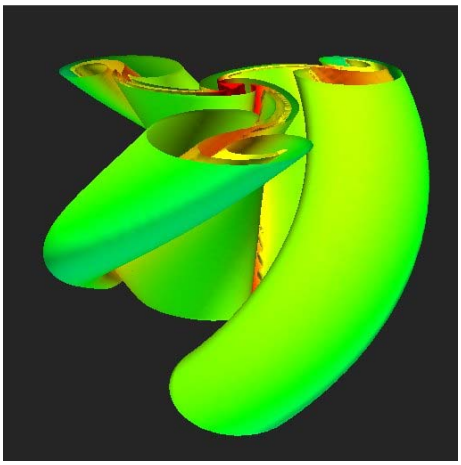

FIG. 2 – vorticity field in the nonlinear phase of Batchelor vortex instability .

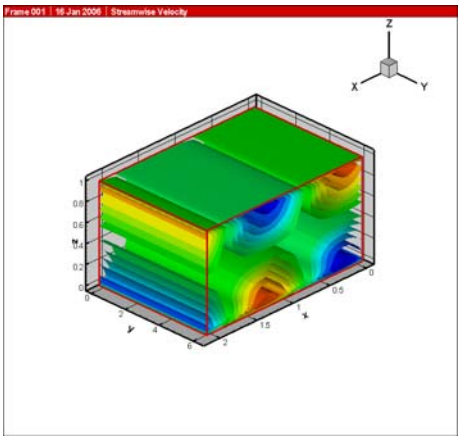

FIG. 3 – Iso vorticity surfaces describing the nonlinear flow in a channel flow with a magnetic field in the cross-stream direction.

working on a channel flow problem in the presence of a magnetic field (figure 3). A new approach of linear stability has been implemented which is called the non normal mode analysis. It is able to quantify the stability of unsteady flows.In addition, this analysis is supplemented by a direct numerical code to investigate the role of nonlinear terms.

Here is a list of general topics in which work could be done :

- *Shear flow Instability in the presence of a Magnetic field.*
- *Instability of a shear layer with non miscible fluids.*

(c) The last theme concerns the study of **extended nonlinear Dynamical systems**. This part is more related to statistical physics problems. For instance, I have recently considered the role of noise on some extended systems. for instance , I have recently performed an analysis considering the time evolution of coupled maps lattices

$$C_{i,j}(t+1) \quad = \quad F\left[C_{i,j}(t)\right] + \sum_{k,l} W_{kl} F\left[C_{k,l}(t)\right] \tag{1}$$

where $F(C)$ is a nonlinear map like a logistic map and $C_{i,j}$ is a field defined at site (i, j) of a discrete two-dimensional lattice.

Another problem related to nonlinear systems was that of the identification of parameters in Biomechanics : based on doppler signals of blood velocity in arteries, one attempts to recover the blood viscosity or the compliance of an artery in an atraumatic way.

Here is a list of general topics in which work could be done :

- *Identification of parameters in Biomechanics.*
- *Modes in Faraday instability*

To get an idea of the various topics, a list of publications can be also examined at the web site locations

http ://www.lmm.jussieu.fr/MEMBRES/ROSSI/publications/rossipublications.html