

Prof. Stephan Fauve

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Prof. Stephan Fauve is one of the most eminent scientists in the field of instabilities and nonlinear phenomena, turbulence, dynamo, etc. He is one of the key scientists of the dynamo experiment in Cadarache that generated a variety of self-generated magnetic field states, including the magnetic field reversals observed in the Earth's magnetic field. He is well known for his instability and chaos work in convection, granular material, and Faraday experiment. He has received several awards and prizes including the IBM prize (Physdics, 1993), the Lewis Fry Richardson Medal of the European Geosciences Union (2009), the Silver medal of CNRC (2009), and the CEA prize, French Academy of Science (2009). He is also the President of the Board of the Statistical and Nonlinear Physics Division of the European Physical Society.

During his visit to IITK he gave two lectures titled Magnetic Field Reversals in Turbulent Dynamos (8th November) and Energy Flux in Turbulence (10th November).

Magnetic Field Reversals in Turbulent Dynamos

8th November 2010

Self-generation of large scale magnetic fields in astrophysical bodies (e.g. planets, stars, galaxies, and galactic clusters) is an important problem of classical physics. In spite of enormous theoretical, numerical, and observational efforts by geo, solar, and astrophysicists, and applied mathematicians, the problem is far from resolved. The French dynamo group, in which Fauve is one of the collaborators, has been able to demonstrate the dynamo mechanism in the Von-Kármán sodium (VKS) experiment. Here, a variety of magnetic field configurations have been observed when liquid sodium is stirred by two impellers (Monchaux et al. 2007, 2009). They observed constant (in time), time-periodic, quasiperiodic, and chaotic magnetic fields by varying the speeds of the impellers. Magnetic field reversals similar to those observed in geo and solar dynamos have also been observed in this experiment. In his talk, Prof. Fauve elaborated this experiment along with his group's theoretical model to explain the phenomena.

CONVERSATIONS

Excerpts from an interview with Prof. Fauve by Nitica Sakharwade and Ish Dhand

It was pleasant to learn that the areas that you're working on are things that we can see around us every day; like the magnetic field of the earth, the air resistance that a spinning cricket ball faces and the turbulence in waves. Please tell us about turbulence and how it manifests in the world around us.

We can cite many examples, starting from short term climate prediction in meteorology. It is a difficult matter to do long term prediction of how climate evolves. Also, turbulence plays a very important role in many engineering processes where you need to mix components very quickly to perform chemical reactions. In the car industry and the airplane industry, turbulence is being studied to improve efficiency. People doing sailing are trained to optimize their boat speed using understanding of turbulence.

The mechanism by which the magnetic field of the earth is produced is a question that has been pondered over for a very long time by the scientific community. Do you think we have, today, reached a breakthrough in understanding the same in the recent experiments carried out in your lab?

Well, not a real breakthrough, but what we've learnt from the experiments is that we don't really need to invoke very complicated mechanisms, such as coupling between the earth's liquid core and something else to generate these reversals in magnetic field. Even a simple laboratory experiment with far fewer parameters was rich enough to display spontaneous reversals of magnetic field which were very similar to the reversals in the earth's magnetic field. We have learnt that we don't need to imagine very complicated mechanics with competition between the earth's liquid core, the earth's mantle and external forces. The system itself, with this volume of liquid metal, is enough to understand the concept.

Perhaps the earlier discoveries regarding the magnetic field were better breakthroughs. For example, the man who discovered that the earth's magnetic field reverses direction made the greatest breakthrough in this field.

How has technology, which is advancing so rapidly today, influenced experimental research and numerical simulations of systems on the computer?

On both sides, it helps a lot. First, you save a lot of time. For instance, 20 years back, which is not too long back, we had to design ourselves many devices which we can today simply buy. The development of this type of technology has helped because you can do the experiment without having to make elaborate preparation for it, and start thinking about the physics behind it. It's not only a question of time. You can make

measurements today that were not possible 20 years ago or were possible with much less precision.

Computers, in some respect, are helping, of course; for instance, once an experiment is running, you can put it on a computer and let it run while you do something else. It's definitely more efficient, but, you may miss out some interesting results. It's always different when you observe the experimental results in real time rather than when you record it on a computer. When you're surprised by the result, for instance, you can immediately change parameters and look at what happens. Of course, the computer will not help in this kind of a situation.

The computer has also helped a lot in numerical simulations, but fortunately, or unfortunately, there still are regimes of turbulence that can be reached by a small experiment on the table, with a small volume of water, that are much larger than what we can calculate even on the best computers in the world today. Yes, we can use numerical recipes to avoid solving exact equations, but direct simulation of flows at Reynolds number 1 million will not only be difficult but impossible. So, computers are nice, but have a limited power.

Then, there are disadvantages of computers. 20 years ago, when you entered a laboratory, you could see people doing an experiment or carrying out calculations by hand or trying to think about a problem. Now when you go to a laboratory, most of the time you'll see people doing things not always connected with research like answering e-mail. It's not clear how this behavior will modify the quality of research. We'll have to see.

We have students from the undergraduate to the PhD level carrying out research here, so what would you suggest to those who want to do real research through experiments?

I suppose that in the beginning they should just follow the lectures and at the same time be curious and begin to think about the subject because the most difficult part in research, I think, is to select a problem. It is very important because research works well if you are able to consider this as a game. The choice should be yours. You should not let someone else, a professor or an advisor, choose a subject for you. I found it very difficult and in fact I spent much more time on visiting laboratories, looking at simple articles not in technical journals but in journals where physics is presented in a simple way, so it took a long time for me to find something really interesting and then when I found something very interesting I began to work on it but it was just like a game so it was very easy to work. I don't think there are clever people who have good ideas and

not clever people who don't have good ideas but there are people who are motivated by their subject so they always think about it. Of course if you spend more time thinking about something finally you get more ideas. So, I suppose there is no age to do research, so a student as soon as he begins his studies, can follow the lectures of different subjects and look at their possibilities. He can choose one, gather information about the subject and go and talk to people in laboratories. For instance, when I was a PhD student the first thing we did was to organize our own informal weekly seminar. We never really talked about our own subject but discussed the interesting articles we had read and explained those to others. So the whole group made a lot of progress in a very short time and at some point prominent professors wanted to follow this seminar.

Complete interview can be accessed at: <http://www.iitk.ac.in/drpg/anreport.htm>