Wolfgang Pauli Institut & „Inst. CNRS Pauli“, IRL2842 du CNRS
Fakultät f. Mathematik, Universität Wien
Fakultät f. Physik, Universität Wien
Forschungsplattform MMM „Mathematics-Magnetism-Materials“
Fakultät f. Fakultät für Geowissenschaften, Geographie und Astronomie

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21. PAULI COLLOQUIUM, jointly with

KOLLOQUIUM der Fakultät für MATHEMATIK

The **Fakultät für Mathematik** jointly with the **Fakultät für Physik,**
the **research platform MMM „Mathematics-Magnetism-Materials”**
and the **Fakultät für Geowissenschaften, Geographie und Astronomie,**
together with the **Wolfgang Pauli Institut** & the **“Inst. CNRS Pauli”,**

kindly invite you to the talk of **Uriel FRISCH** (CNRS)

Time: Wednesday, 21. Sep 2022, 15:55 – 17:15

Place: Hörsaal 13, 2nd floor, Oskar-Morgenstern-Platz 1, 1090 Wien

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1) 15h55 – 16h15 : **Coffee & Cake**

2) 16h15 – 16h20 : **Introduction :** Norbert J **Mauser** (U.Wien & WPI & CNRS)

3) 16.20 – 17.15 Uhr :

Uriel Frisch (Lab. J.L. Lagrange, Observatoire de la Côte d'Azur, CNRS, Nice)

“From Leonardo da Vinci to Andrei Kolmogorov to Giorgio Parisi :
Five Centuries of Temporal Decay of Turbulence .”

Radu Bot (Dean Math) ***Martin Fally*** (Dean Physics) ***Petra Heinz*** (Dean Geo/Astro) ***Norbert J Mauser*** (director WPI & Inst CNRS Pauli)

Abstract:

Leonardo da Vinci (1452-1519) had a strong interest in hydrodynamics, particularly in the last 15 years of his life. Around1505, in one of his mostly famous notebooks, Leonardo got interested in "turbulence" (he was the first to propose this name). Examining the "turbulences" (eddies) in the river Arno of Florence, he found that the amplitude of the turbulence was decreasing very slowly in time, until it would come to rest (within the surrounding river) [1].
In spite of Leonardo's strong interested in mathematics, at that time, it consisted basically of geometry and simple polynomial equations. There were no tools able to describe the very slowly temporal relaxation of turbulence.
This topic would remain dormant for about 430 years, until in 1938 Kármán [2], triggered by Taylor, established that the mean energy of the turbulence should decrease very slowly, indeed like an inverse power of the time elapsed. Three years later, Kolmogorov [3] found a algebraic mistake in Kármán's calculation; Kolmogorov himself found another inverse power (10/7) of the time elapsed. This, likewise was wrong, because he was assuming a certain invariance property (Loitsiansky [4]), proved later wrong by Proudman and Reid [5]. The main change in the last few decades is that fully developed turbulence is definitely not self-similar, not only is it fractal (as proposed by Mandelbrot), but it can have infinitely many fractal scalings (multifractality), as proposed by Parisi and Frisch in the eighties [6].
Furthermore, multifractality can manifest itself either at small scales or at large scales. The latter might change the law of energy decay. Not enough is understood for the 3D Euler equations, but large-scale multifractality for the Burgers is an interesiing possiibility, which is being explored by Frisch, Khanin, Pandit and Roy. A brief exploration of what happens to the energy decay-law will be presented.
Will there soon be an IR-multifractal theory of the energy decay of turbulence?

[1] Frisch, U. 1995 "Turbulence. The legacy of A.N. Kolmogorov", CUP (p. 112).
[2] Karman, T. and Howarth, L. 1938. On the statistical theory of isotropic turbulence. Proc. Roy. Soc. London, Series A, vol. 164, 192-215.
[3] Kolmogorov, A.N. 1941. On degeneration of isotropic turbulence in an incompressible viscous liquid. Doklady Akad. Nauk SSSR, vol. 31, 838.
[4] Loitsiansky, L.G. 1939. Some basic laws for isotropic turbulent flow. C.A.H.I. (Moscow), Rept. 440.
[5] Proudman, I. and Reid, W.H. 1954. On the decay of a normally distributed and homogeneous turbulent velocity field, Philosoph. Trans. Royal Soc. London, Series A. Mathematical and Physical Sciences, vol. 247, pp. 163-189.
[6] Parisi G. and Frisch U. 1985 "On the singularity structure of fully developed turbulence", in Proceed. Turbulence and predictability in geophysical fluid dynamics and climate

Short Biography:

Uriel Frisch (born 19 December 1940 in Agen, France) is a French physicist of fluid mechanics, of cosmology and of applied mathematics, specialist on turbulence. Frisch was a student at the École Normale Supérieure and earned a Ph.D. in 1967 from the University of Paris. He published over 200 papers and a well-known book on the work of Kolmogorov.

Key discoveries :

Intermittency and complex singularities. Experimental data on turbulence show evidence that high-order derivatives present intermittent puffs. Frisch and Morf proved that such puffs are associated to complex singularities.

Multifractality. Turbulence data show that, at scales where forcing and dissipation are negligible, the moments of velocity increments, scale as powers of the separation. Parisi and Frisch showed that the exponents have non-trivial dependence on the order. This effect, which connects with the foundation of the entropy in statistical physics is called multifractality (presence of infinitely many fractal dimensions). This is one of the many topics for which Giorgio Parisi got the Physics Nobel Prize in 2021.

Lattice Hydrodynamics. Frisch, Hasslacher and Pomeau showed that there exist cellular automata on suitable lattices that simulate the Navier-Stokes dynamics. Variants, using the same lattices, but with the Boltzmann approximation, are now frequently used for simulating flows around vehicles and airplanes.

Key prizes: Peccot Prize of the Collège de France for his doctoral thesis in 1967.
Elected as Correspondant of the French Academy of Science (1994), Full Member in 2008.
Lewis Fry Richardson Prize of the European Geoscience Union (2003). Applied Mechanics Prize Modesto Panetti e Carlo Ferrari of the Turin Academy of science (2010). EUROMECH Prize (fluid mechanics) 2020.