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Università di Roma Tor Vergata
Dipartimento di Fisica

Università di Roma
Tor Vergata

Seminar

Friday, 6 March 2015 - h. 14:30

Sala Grassano (Dipartimento di Fisica)

Prof. Uriel Frisch

Observatoire de la Cote d'Azur
CNRS - France

"Time-analyticity of Lagrangian particle trajectories in ideal fluid flow governed by the Euler equations: historical and modern perspectives"

Abstract

Two prized papers, one by Augustin Cauchy in 1815, presented to the French Academy and the other by Hermann Hankel in 1861, presented to Goettingen University, contain major discoveries on vorticity dynamics whose impact is now quickly increasing.

(i) Cauchy found a Lagrangian formulation of 3D ideal incompressible flow in terms of three invariants that generalize to three dimensions the now well-known law of conservation of vorticity along fluid particle trajectories for two-dimensional flow. This has very recently been used by Zheligovsky and Frisch to prove analyticity in time of fluid particle trajectories for 3D incompressible Euler flow and can be extended to compressible flow, in particular to cosmological dark matter.

(ii) Hankel showed that Cauchy's formulation gives a very simple Lagrangian derivation of the Helmholtz vorticity-flux invariants and, in the middle of the proof, derived an intermediate result which is the conservation of the circulation of the velocity around a closed contour moving with the fluid. This circulation theorem was to be rediscovered independently by William Thomson (Kelvin) in 1869. Cauchy's invariants were only occasionally cited in the 19th century - besides Hankel, foremost by George Stokes and Maurice Levy - and even less so in the 20th until they were rediscovered via Emmy Noether's theorem in the late 1960, but reattributed to Cauchy only at the end of the 20th century by Russian scientists.

The presentation is based in part on the two following papers:

* Frisch, U. and Villone, B. 2014. Cauchy's almost forgotten Lagrangian formulation of the Euler equation for 3D incompressible flow, EPJ H vol. 39, pp. 325--351. arXiv:1402.4957 [math.HO]
* Zheligovsky, V. and Frisch, U. 2014. Time-analyticity of Lagrangian particle trajectories in ideal fluid flow, J. Fluid Mech., vol. 749, pp. 404--430. arXiv:1312.6320 [math.AP]

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