Two mathematical challenges in plasma physics

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Sobre o orador: Daniel Peralta-Salas (Madrid, 1978) is a senior scientific researcher at the Institute of Mathematical Sciences (ICMAT) in Madrid (Spain). Since 2017 he is the Chair of the Group "Differential Geometry and Geometric Mechanics". He got a PhD in Mathematical Physics at Complutense University (Madrid, Spain) in 2006 and after postdoctoral positions he joined the ICMAT in 2010. He has published more than 100 research articles in high profile journals, such as Annals of Mathematics, Acta Mathematica, Duke Mathematical Journal or PNAS, and has been an invited speaker in more than 120 international conferences, seminars and courses. Among his main distinctions we highlight the Plenary Lecture he gave at the European Congress of Mathematics in 2016 (Berlin, Germany), the Barcelona Dynamical Systems Prize (2015) and the Floer Lectures at the Floer Center of Geometry in 2019 (Bochum, Germany). In 2023 he was the EMS distinguished speaker at the Nordic Congress of Mathematicians (Aalborg, Denmark). During the period 2014-2019 he was the PI of the Starting Grant from the European Research Council (ERC) "Invariant manifolds in Dynamical Systems and PDE".

Sumário

From the mathematical viewpoint, plasmas are described by a combination of the Navier-Stokes equations and Maxwell equations, which results in the so called magnetohydrodynamics (MHD) equations. When the fluid is a perfect conductor, the resistivity of the plasma is neglected and it is described by the ideal MHD equations, which is a good approximation to study solar active regions and plasma confinement near equilibrium configurations. In this talk I will review two classical problems in mathematical plasma physics that remain open. The first one concerns the geometric structure of MHD equilibria (Grad's conjecture, 1967) and the second one is related to the phenomenon of magnetic relaxation and its topological obstructions (Parker, 1972). Recent advances by the speaker and collaborators include the construction of counterexamples of low regularity to Grad's conjecture, and the proof of Parker's hypothesis in axisymmetric toroidal domains. The use of modern tools from the theory of dynamical systems (KAM, Newhouse phenomena) is key for both results.