The initial value problem of Force-free Electrodynamics in Euler Potentials

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ABSTRACT

It is well known that in the neighborhood of a pulsar or a black hole, the presence of strongly magnetic fields gives rise to the generation of a very diluted plasma. In that region, the electromagnetic field dominates over the matter constituting that plasma, and the resulting uncoupled dynamics is commonly known as Force-free Electrodynamics.

In this talk I will present a recent result [1] about the initial value problem of considering Force-free Electrodynamics in Euler Potentials. We prove that the initial value problem for Force-free Electrodynamics in Euler variables is not well posed, establishing this result by showing that a well-posedness criterion provided by Kreiss [2] fails to hold for this theory, and using a theorem provided by Strang [3].

To show the nature of the problem I will display a particular bounded (in Sobolev norms) sequence of initial data for the Force-free equations such that at any given time as close to zero as one wish, the corresponding evolution sequence is not bounded. Thus, the Force-free evolution is non continuous in that norm with respect to the initial data, implying that this formulation should not be used in numerical simulations or other kinds of approximations for simulating dynamics of accretion disks around spinning black holes. Growing linear perturbations will become arbitrarily stiff as the grid frequency is increased, and furthermore non-linearities can alter that growth making it to become exponential and thus rendering computations nonsensical.

References

[1] O. A. Reula and M. E. Rubio. Ill-posedness of Force-free Electrodynamics in Euler Potentials. *Physical Review D* **95**(064005):1-14, 2017.

[2] Heinz-Otto Kreiss and Jens Lorenz. Initial Boundary Value Problems and the Navier-Stokes Equations. Academic Press, San Diego, USA, ISBN 0-12-426125-6, 1989.

[3] Gilbert Strang. Necessary and insufficient conditions for well-posed Cauchy problems. *J.Differential equations*, **2** 107-114, 1966.