A New Formulation of Relativistic Euler Flow: Miraculous Geo-Analytic Structures and Applications

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I will discuss my recent joint work with M. Disconzi on the relativistic Euler equations with non-trivial vorticity and entropy. We derived a new formulation of the equations exhibiting miraculous geo-analytic structures, including I) A sharp decomposition of the flow into geometric “wave parts” and “div-curl-transport parts;” II) Null form source terms; and III) Structures that allow one to propagate one additional degree of differentiability (compared to standard estimates) for the vorticity and entropy. We were inspired to search for such a formulation by i) Christodoulou’s groundbreaking 2007 monograph on shock formation in irrotational and isentropic regions and ii) my work with J. Luk, in which we derived a similar new formulation for the non-relativistic compressible Euler equations. I will then describe how the new formulation can be used to derive sharp results about the dynamics, including results on stable shock formation and the existence of low regularity solutions. I will emphasize the role that nonlinear geometric optics plays in the framework and highlight how the new formulation allows for its implementation. Finally, I will connect the new formulation to the broader goal of obtaining a rigorous mathematical theory that models the long-time behavior of solutions that can develop shocks.