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Toward a Full MHD Jet Model of Spinning Black Holes. Kinematics and Application to the M87 Jet

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We investigate the magnetohydrodynamical structure of a jet powered by a spinning black hole, where electromagnetic fields and fluid motion are governed by the Grad–Shafranov equation and the Bernoulli equation, respectively. When a steady and axisymmetric jet structure is assumed, the global solution is uniquely determined with the prescribed plasma loading into the jet and the poloidal shape of the outmost magnetic field line. We apply this model to the jet in the center of the nearby radio galaxy M87, and we find that it can naturally explain the slow flow acceleration and the flow velocity stratification within 10ˆ5 gravitational radii from the central black hole. In particular, we find that the extremal black hole spin is disfavored by the flow velocity measurements if the plasma loading into the jet is dominated by the electron-positron pair production at the jet base.

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