Two-temperature advective transonic accretion flows around black holes

Shilpa Sarkar ; Indranil Chattopadhyay

Accretion onto black holes are one of the most energetic processes happening in the Universe. This process provides us with the explanation of the huge amount of energy liberated and high luminosities observed in AGN's, X-ray binaries etc. Modeling of these accretion-flows is necessary to obtain a proper picture of the processes and phenomena going on. Since electrons are the ones which radiate via processes like synchrotron, bremsstrahlung and inverse-Compton scattering, therefore the electron gas and proton gas, present in the ionized plasma of the accretion disk, are supposed to settle down at two different temperatures, hence the name two-temperature. Not much work has been done in two-temperature accretion flows, so we addressed this problem in greater details in the pure general-relativistic regime. The problem with two-temperature flow is that, there is one more variable than the number of equations. Assuming axis-symmetry, we have four equations of motion, while there are five flow variables: v_r, v_\phi, electron temperature (Te), proton temperature (Tp) and density. Solving the equations of motion for a given set of constants of motion, we find that no unique solution exists unlike in the case of one-temperature flows or in other words the solutions are degenerate. So, for different combinations of the flow variables we get different kinds of transonic solutions with drastically different topologies, but for the same set of constants of motion. In addition, there is no known principle dictated by plasma physics which may constrain the relation between these two-temperatures in any of the boundaries. We removed the degeneracy with the help of second-law of thermodynamics. We show that only one of the solutions among all, has the maximum entropy and therefore is the correct solution, thus eliminating degeneracy. As far as we know no methodology of obtaining unique transonic two-temperature solutions has been reported so far in literature. This is the first time we have attempted towards obtaining the general-picture of the physical solutions.