Catastrophic Formation of Macro-Scale Flow and Magnetic Field in the Relativistic Gas of Binary Astrophysical Systems

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Applying the quasi-equilibrium analysis [1,2] to explore the explosive/eruptive events we have studied a quasi-neutral multi-species plasma of a mobile classical ion component, and two relativistic electron components (the bulk degenerate electron gas with a small contamination of hot electrons) characteristic for the binary systems. We found analytically the condition of the catastrophic transformation of energies; the catastrophe results because slow changes in the initial parameters drive the system into a regime that the governing Quadruple Beltrami state can, no longer, be sustained. The system must find a new equilibrium (typically a lower order Beltrami state) with vastly different mix of energies - flow kinetic, thermal and magnetic. In one such scenario, macro-scale flow-kinetic, and magnetic energies abound in the final state. For the given multi-component plasma, we show that the flow (strongly Super-Alfvènic) kinetic energy is mostly carried by the small hot electron component; under specific conditions, it is possible to generate strong macro-scale magnetic (velocity) field when all of the flow (magnetic) field energy is converted to the magnetic (velocity) field energy at the catastrophe. We have shown that this transformation is guaranteed in multi-temperature, multi-component systems as an intrinsic tendency of flow acceleration/magnetic field amplification due to what can be labelled as magneto-fluid coupling. The former scenario could explain the magnetic WDs related to the binary interactions during the post-main-sequence phases of star evolutions. The model can also be applied, for example, to describe the explosive/eruptive phenomena occurring in the binaries, specifically in the outer layer of the dense/degenerate WD's that accrete a classical hot flow.

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References

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