

# **Emergence of Rings with Spiral Structures Around Shining Black Holes, Magnetic Field Generation Processes and High Energy Particle Populations\***

*Bruno Coppi (Massachusetts Institute of Technology)*

“Shining” Black Holes are considered to be surrounded by high energy plasmas responsible for the emitted radiation. These plasmas can have a variety of spatial configurations and exhibit a multiplicity of experimentally observed “states” (i.e. plasma regimes). Magneto-Gravitational Modes [1] are shown to emerge from “classical” plasma disks surrounding black holes and imbedded in very weak magnetic fields. These involve the formation of rotating plasma rings with trailing and tight spiral structures.

The relevant tri-dimensional structures are consistent with the observation of the so called Quasi Periodic Oscillations of the X-ray emission in the vicinity of rotating black holes. Moreover, these modes can lead to the generation of magnetic fields with significant amplitudes over large scale lengths providing a well founded theoretical basis for this generation process.

Stationary axisymmetric configurations involving solitary rings or ring sequences are found as non-linear solutions of the relevant “equilibrium” equations without requiring the presence of a background (seed) magnetic field[1].

A theory including the presence of high energy particle populations, consistent with the radiation emission characteristics in significant “states” of shining black holes and involving non-thermal distributions in phase space (in the simplest cases represented by non-isotropic temperatures) has been developed. This presence is shown to have important effects both on the magneto-gravitational modes that can be excited and on the non-linear stationary plasma and field configurations that can be identified.\*Sponsored in part by the U.S. Department of Energy.

[1] B. Coppi, *A&A* 548, A84 (2012).