THERMAL RADIATION FROM AN ACCRETION DISK

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An effect of stimulated radiation processes on thermal radiation from an accretion disk is considered. The radial density waves triggering flare emission and producing quasi-periodic oscillations in radiation from an accretion disk are discussed. It is argued that the observational data suggest the existence of the weak laser sources in a two-temperature plasma of an accretion disk.

It was shown earlier that thermal radio emission has a stimulated character and that this statement is probably valid for thermal blackbody radiation in others spectral ranges (Prigara 2003). According to this conception thermal radiation from non-uniform gas is produced by an ensemble of individual emitters. Each of these emitters is an elementary resonator the size of which has an order of magnitude of mean free path of photons, \( l = 1/(\nu n \sigma) \), where \( n \) is the number density of particles, and \( \sigma \) is the absorption cross-section.

The emission of each elementary resonator is coherent, with the wavelength \( \lambda = l \), and thermal radiation from a gaseous layer is incoherent sum of radiation produced by individual emitters. This dependence of the wavelength on the density is consistent with the experimental results by Looney and Brown on the excitation of plasma oscillations (Alexeev 2003).

In the gaseous disk model (Prigara 2003), the density depends upon the distance \( r \) from the energy center as follows:

\[
n \propto \left( v_0^2 r^2 + c^2 r_s r \right)^{-1/2},
\]

where \( r_s \) is the Schwarzschild radius, \( c \) is the speed of light, and \( v_0 \) is a constant. This density profile is consistent with the convection dominated accretion flow (CDAF) models or the advection dominated accretion flow (ADAF) models with an outflow (Nagar et al. 2001).

The last equation gives the wavelength dependence of the emitting region size \( r_\lambda \) in the form \( r_\lambda \propto \lambda^2 \) at small values of the radius, and \( r_\lambda \propto \lambda \) at the large radii. These relations are indeed observed in radio band for compact and extended radio sources respectively. Compare these results with the Lyndell-Bell’s relation \( r_\lambda \propto \lambda^{4/3} \).

Some X-ray binaries, e.g. Sco X-1, show weak emission lines with the variable intensities and radial velocities. These features are characteristic for non-saturated lasers. The wavelength of generated mode is determined by the size of an elementary resonator which is depending on the density. The radial density wave travelling along the radius changes the density which results in the variations of the wavelength. Convection or advection in the gaseous disk produces a two-temperature plasma in which it is possible to create the inversion of the energy level population. This gives rise to the weak lasers similar to the weak molecular masers.

The radial density wave produces also the delay of flares at low frequencies and high frequency quasi-periodic oscillations observed in X-ray binaries. Density waves can presumably propagate in a sufficiently hot plasma of an accretion disk. They differ from the shocks, since the density waves have the smooth density and pressure profiles.

The density waves in a hot plasma seem to have been observed in a solar microwave burst, causing the strong correlation in the modulation of radio and X-ray emission over a large distance \( (10^{16} \text{cm}) \) in the solar corona (Grechnev et al. 2003).

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