Transfer of gyroresonant radiation in neutron star atmospheres

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We analyze radiation transfer and calculate radiation pressure force in the electron cyclotron line in the atmospheres of neutron stars. We specify the atmospheric parameters for which an outflow of plasma is possible under the radiation pressure in the cyclotron line. It is shown that the correct results can only be obtained using dielectric tensor for mildly relativistic plasmas in strong magnetic field, which is derived taking into account relativistic corrections to the cyclotron resonance condition, as well as the effects of vacuum polarization and recoil during photon scattering. The real and imaginary parts of the refraction indices and polarization coefficients for electromagnetic eigenwaves under the conditions, where scattering dominates absorption, are derived. We show that relativistic effects and vacuum polarization play a significant role in the radiation transfer and determine the radiation pressure on a plasma for a wide range of parameters of neutron star atmospheres. In particular, relativistic corrections to the gyroresonance condition lead to the escape of radiation from the cyclotron line and, hence, to a decrease in radiation pressure force; this effect turns out to be crucial not only in a plasma with relativistic electron temperatures, but also even in a non-relativistic plasma. It is shown that vacuum polarization contributes to the increase in radiation pressure force due to the sharp rise in the scattering cross section for an ordinary wave in the outer atmosphere. The above factors lead to an extension of the range of parameters for which the existence of a static atmosphere is not possible, i.e., they relax the conditions for the formation of flows under radiation pressure in the cyclotron line.