Astronomy and Astrophysics 2010 vol.522 N8

Radiative properties of highly magnetized isolated neutron star surfaces and approximate treatment of absorption features in their spectra

Suleimanov V., Hambaryan V., Potekhin A., Van Adelsberg M., Neuhäuser R., Werner K.
Kazan Federal University, 420008, Kremlevskaya 18, Kazan, Russia

Abstract

Context. In the X-ray spectra of most X-ray dim isolated neutron stars (XDINSs), absorption features with equivalent widths (EWs) of 50-200 eV are observed. These features are usually connected with the proton cyclotron line, but their nature is not yet well known. Aims. We theoretically investigate different models to explain these absorption features and compare their properties with observations to obtain a clearer understanding of the radiation properties of magnetized neutron star surfaces. Based on these models, we create a fast and flexible code to fit observed spectra of isolated neutron stars. Methods. We consider various theoretical models of the magnetized neutron star surface, including naked condensed iron surfaces and partially ionized hydrogen model atmospheres, with semi-infinite and thin atmospheres above a condensed surface. Spectra of condensed iron surfaces are represented by a simple analytical approximation. The condensed surface radiation properties are considered as the inner atmosphere boundary condition for the thin atmosphere. The properties of the absorption features (especially equivalent widths) and the angular distributions of the emergent radiation are described for all models. A code for computing light curves and integral emergent spectra of magnetized neutron stars is developed. We assume a dipole surface magnetic field distribution with a possible toroidal component and corresponding temperature distribution. A model with two uniform hot spots at the magnetic poles may also be employed. Results. Light curves and spectra of highly magnetized neutron stars with parameters typical of XDINSs are computed using different surface temperature distributions and various local surface models. Spectra of magnetized model atmospheres are approximated by diluted black-body spectra with one or two Gaussian lines having parameters, which allow us to describe the model absorption features. The EWs of the absorption features in the integral spectra cannot significantly exceed 100 eV, if a local surface model assumes either a semi-infinite magnetic atmosphere or a naked condensed surface. A thin atmosphere above a condensed surface can have an absorption feature whose EW exceeds 200 eV in the integrated spectrum. If the toroidal component of the magnetic field on the neutron star atmosphere is 3-7 times higher than the poloidal component, the absorption feature in the integral spectrum is too wide and shallow to be detectable. Conclusions. To explain the prominent absorption features in the soft X-ray spectra of XDINSs, we infer that a thin atmosphere above the condensed surface must be present, whereas a strong toroidal magnetic field component on the XDINS surfaces can be excluded. © 2010 ESO.

http://dx.doi.org/10.1051/0004-6361/200913641

Keywords

methods: numerical, radiative transfer, scattering, stars: atmospheres, stars: neutron, X-rays: stars