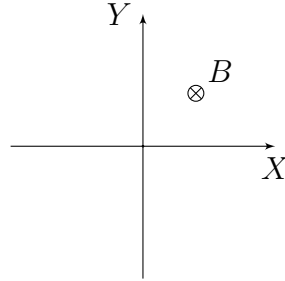


T9. Cyclotron resonant scattering features

The X-ray spectrum of neutron stars contains absorption lines that allow direct measurement of the magnetic field strength near the surface of neutron stars: cyclotron resonant scattering features.

Their nature is related to the fact that a charged particle (e.g., an electron) performs periodic motion in a magnetic field and, under certain conditions, interacts strongly with the incident EM wave.



Let's discuss an electron with charge $-e$ and mass m moving in the plane XY perpendicular to the uniform magnetic field B .

A1	Obtain the equations of motion for the electron in the form $\begin{cases} \ddot{X} = \dots \\ \ddot{Y} = \dots \end{cases}$
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A2	Integrate the second equation with respect to time, and using substitution, obtain the equation of harmonic oscillations $\ddot{X} + \omega_0^2 X = C.$ Express ω_0 in terms of m , e and B .
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Let's imagine that an EM wave with complex amplitude E and frequency ω falls normally to the XY plane on an electron moving in this way. Wave polarization is linear along the X axis.

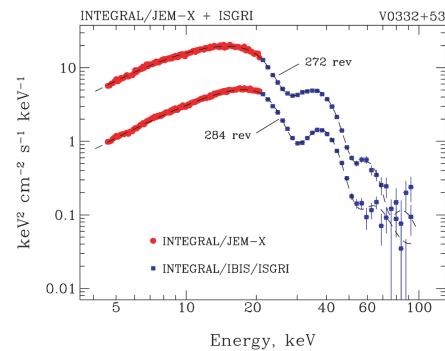
Then the motion of the electron can be considered within the framework of perturbation theory. Let $X(t)$ and $Y(t)$ be the solutions to the initial problem (without the EM wave), and $X(t) + x(t)$ and $Y(t) + y(t)$ be the solutions to the complete problem.

A3	Similarly to question A1 , obtain the equation of motion for $x(t)$ and $y(t)$.
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A4	Similarly to question A2 , eliminate y and obtain the equation of forced oscillations for $x(t)$.
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A5	What is the frequency of EM wave ω when the resonance takes place?
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In the X-ray spectra of objects with strong magnetic fields, the resonance under consideration is observed as an absorption line in a smooth dependence $\Phi(E)$, where Φ is the flux density of photons with energy E arriving from the object under study.



$\Phi(E)$ fot the V0332+53 pulsar. S. Tsygankov et al. 2006.

A6	From the quantum point of view explain the presence of several cyclotron resonant scattering features. Obtain the value of the mean magnetic field B on the surface of the V0332+53 pulsar.
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