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MHD wave modes of solar magnetic flux tubes with the realistic cross-section

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Current and near-future high resolution solar observations indicate that theoretical modelling of the magnetohydrodynamic (MHD) modes in magnetic waveguides with realistic structure and shape now becomes an imperative necessity.

It was recently shown that even a magnetic structure with elliptical shape, that corresponds to the weak irregularity, may significantly influence the spatial structure of MHD mode in comparison to the mode structure obtained from the modelling which is based on the magnetic flux tube shape with cylindrical cross-section (Aldhafeeri et al., ApJ, 2021). An inaccurate model used for describing waves may lead to the misinterpretation of observational data.

The expressions for the linear MHD perturbations of a magnetic flux tube are derived by assuming zero value of the vertical component of the velocity perturbation at the boundary of the magnetic flux tube, which is in good agreement with observations. The governing equation for the vertical velocity perturbation was solved by taking into account the observed realistic shape of the sunspot umbra. With these conditions the proposed model is applicable for the analysis of slow body modes under photospheric conditions.

Our results show that under solar photospheric conditions the conditions of continuity of the component of radial velocity and pressure at the boundary are enough to be imposed, enabling us to use Cartesian coordinates with varsity numerical methods to model the MHD modes with their realistic cross-sectional shape.