Global geodesic acoustic modes in tokamak in the framework of two-fluid MHD

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Geodesic acoustic modes (GAM) are the low-frequency electrostatic oscillations observed in many tokamaks in both ohmic and L-regimes [1]. GAMs are believed to play a crucial role in turbulent tokamak transport, besides GAMs can be used for MHD spectroscopy of plasmas. This explains the high interest in GAM studies. One of the important peculiarities of the experimentally observed GAMs is their global character, i.e. these oscillations have a certain frequency in the whole plasma volume. In the frame of ideal single-fluid MHD, the global GAMs were found numerically [2] and analytically [3] for the plasmas with specific profiles of temperature and magnetic field, which did not quite correspond to usual conditions of experiments. But so far there is no satisfactory theory that can explain globality of GAMs for typical profiles of experimental discharges.

In the present work, the global GAMs are studied in the frame of two-fluid MHD. It is shown that for a tokamak with a large aspect ratio, cold ions and circular concentric magnetic surfaces the low-frequency axisymmetric oscillations of electron pressure $\tilde{p}$ are described by the equation:

$$ω^{2}\tilde{p}=\frac{C\_{S}^{2}(r)}{R\_{0}^{2}}\left[2\tilde{p}\_{1s}\left(r\right)\sin(θ-\frac{1}{q^{2}(r)})\tilde{p}\_{θθ}^{''}-2iω\frac{R\_{0}}{rΩ\_{ci}}\left(\tilde{p}\_{θ}^{'}\cos(θ+r\tilde{p}\_{r}^{'}\sin(θ))\right)\right]. (1)$$

Here $ω$ is the eigen-frequency of oscillations, $C\_{S}$ is the sound speed, $R\_{0}$ is the large radius, $q$ is the safety factor, $Ω\_{ci}$ is the ion Larmor frequency on the magnetic axis, $r$ is the radial coordinate, $θ$ is the poloidal angle. The term linear in $ω$ is due to two-fluid effects, it is responsible for coupling of poloidal harmonics and globality of eigen-modes. Equation (1) was solved numerically for typical experimental profiles of $C\_{S}(r)$ and $q(r)$. Found eigen-frequencies $ω$, corresponding to eigen-solutions of equation (1), are always real and form a discrete spectrum, which is characteristic for global modes. The numerical results are in good correspondence with available experimental data.

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References

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