Singular global components and frequency shift of the continuum GAMs in shaped tokamak plasmas

C. Wahlberg\(^1\) and J. P. Graves\(^2\)

\(^1\)Department of Physics and Astronomy, P.O. Box 516, Uppsala University, SE-751 20 Uppsala, Sweden. \(^2\)Ecole Polytechnique Fédérale de Lausanne (EPFL), Swiss Plasma Center (SPC), CH-1015 Lausanne, Switzerland.

Geodesic acoustic modes (GAMs) of a global character are frequently observed in tokamak plasmas. While many aspects of GAMs require a kinetic treatment, the MHD model offers a suitable framework for analytically studying various global aspects of these modes, including higher-order effects of plasma shaping, plasma flows, and the magnetic perturbations connected with the GAM [1]. In this contribution, we extend the MHD analysis in [1] in order to study two additional aspects of the GAM. We first show that, as a part of the continuous MHD spectrum, the GAM eigenfunctions include components that exist outside the GAM surfaces and have singularities of type \((\psi - \psi_0)^{-1}\) or \(\ln|\psi - \psi_0|\), where \(\psi\) is a flux function that labels the magnetic surfaces, and \(\psi = \psi_0\) defines the singular (or GAM) surface [2]. Hence, in addition to the \(m = 0\) and \(m = 1\) delta function components of the plasma flow and of the density and pressure perturbations existing at the GAM surface, the GAM continua also include \(m = 0\) and \(m = 1\) singular components varying as \((\psi - \psi_0)^{-1}\) near \(\psi = \psi_0\), and extending from the plasma centre to the edge. This gives these Fourier components of each GAM in the continuum a global character.

We also calculate the effects of a finite aspect ratio and a non-circular plasma cross section on the GAM frequency, and recover the dependence on inverse aspect ratio and Shafranov shift of the GAM frequency previously derived within gyrokinetic theory by Gao [3]. While the dominating shaping effect on the GAM frequency comes from plasma elongation, we show here that there is a higher-order triangularity effect that can also be significant. The calculated triangularity effect predicts a nearly linearly increasing GAM frequency with increasing triangularity, a phenomenon observed also in the TCV tokamak.