Study of low n Kinetic Ballooning Mode in Spherical Tokamak

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ABSTRACT

- Low n kinetic ballooning modes (KBM) are studied for plasma relevant to spherical reactor tokamaks
- The long wavelength KBM are excited as the equilibrium beta is increased systematic.
- The basic character of temperature and density gradient driven KBM remains same but the former supports the existence of other modes
- Inclusion of energetic ions excites KBM even at a lower beta and mode becomes localized towards longer wavelengths.

BACKGROUND

- An important parameter for efficient spherical reactor is the maximum achievable beta. For a given magnetic field the aim is to build reactors that can sustain higher pressure.
- The global MHD modes however, can set an upper limit to this achievable beta and can incur sudden deterioration of plasma.
- One such instability is long wavelength kinetic ballooning mode, which exhibit properties like ideal MHD modes but with kinetic modifications
- Because of the high beta in the fusion spherical reactors these global modes can become active and set a hard limit on beta .
- The presence of large amount of energetic ions may lead to interaction of the the long wavelength KBM and aggravate the situation even further.

OBJECTIVE and TOOLS

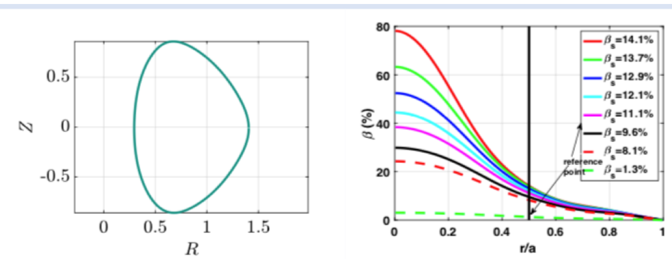
The objective of the present work twofold
-study the long wavelength KBM without energetic ions
- explore the interaction of the KBM with energetic ions

TOOLS USED

1. Using the Grad-Shafranov solver CHEASE [1,2] code we generate a series of numerical equilibria varying in beta. The equilibria encapsulate the region of electrostatic to electromagnetic transition

2. The Miller parameters extracted from these equilibria are then fed the gyrokinetic code GENE to study instabilities pertaining to these equilibrium. The objective of this exercise is to take account consistently the effect of plasma shape, Shafranov shift etc. with varying beta.

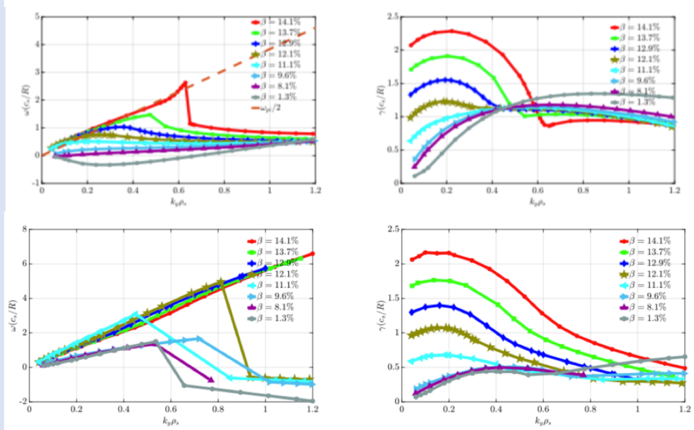
3. Figures bellow represents the plasma surface shape and beta values for different equilibria used in the simulations.



Left: Last closed Flux surface; Right: Radial profile of beta

RESULTS: GK simulations w/o energetic ions

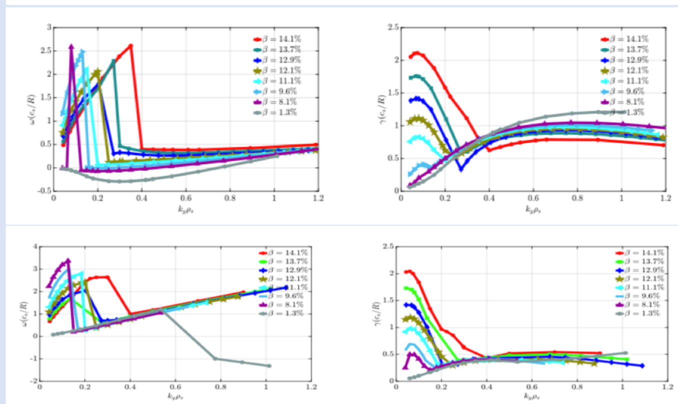
***Unstable long wavelength KBM observed driven by density and temperature gradients, Growth rates increases as beta increases, peaked at longer wavelength, Agree well with MHD predictions:**



Density gradient (upper) and temperature (lower) gradient driven KBM

RESULTS: GK simulations w/ energetic ions

***Energetic ions make the long** wavelength KBM unstable even lower beta. Mode is more localized towards longer wavelength, Real frequency increases.



Density gradient (upper) and temperature (lower) gradient driven KBM

CONCLUSION

- Unstable long wavelength KBMs observed for reactor relevant spherical tokamak. Plasmas, that exhibit ideal MHD character and global
- The modes are driven by both density and temperature gradients
- Energetic ions make the mode more localized at even longer wavelength.
- The beta threshold for the onset of longer wavelength KBM is decreased in the presence of energetic ions. Energetic ions precession frequency plays important role in defining real frequency of the mode.
- Global analysis might be needed to explore these modes..

REFERENCES

[1] Luetjens H et al, Comput. Phys. Commun. 69 287 (1992) and 97 219 (1996), [2] O. Sauter et al 2013 Comput. Phys. Commun. 184 293, [3] Jenko F et al Phys. Plasmas 7 1904 (2000),[4] G¨orler T et al J. Comput. Phys. 230 7053 (2011),[5] http://genecode.org/

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