The systematic investigation of energetic particle driven geodesic acoustic mode channeling using MEGA code

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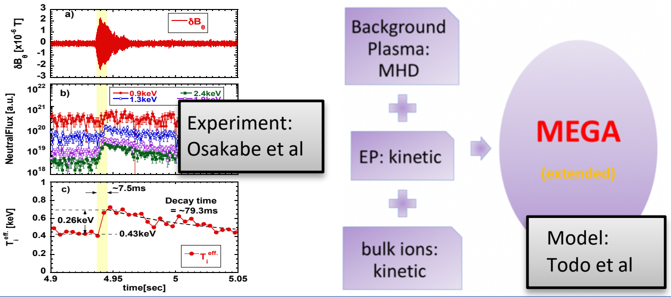
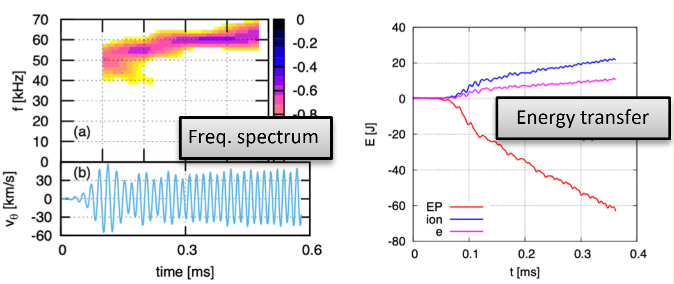
Introduction

- EGAM is an Energetic Particle Driven Geodesic Acoustic Mode
- EGAMs are observed in many devices including JET, DIII-D, LHD, AUG, HL-2A, EAST, KSTAR et al.
- EGAM channeling is investigated experimentally and theoretically. [M. Osakabe FEC2014] [M. Sasaki PPFC 2011]
- The hybrid code MEGA is used to simulate the EGAMs. Both the energetic particles and bulk ions are described by kinetic equations.



Energy Transfer [H. Wang et al NF 2019]

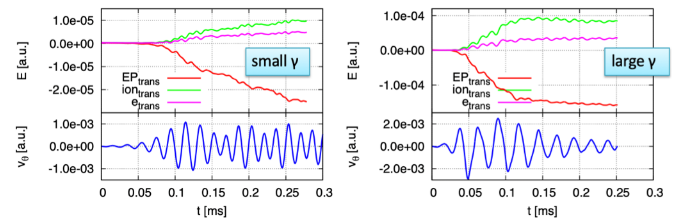


- EGAM channeling is reproduced using MEGA code. From 0.1 ms to 0.15 ms, the average bulk ion heating power is 96.1 kW, or, 3.2 kW/m^3.
- The sideband resonance is dominant during the energy transfer from EGAM to the bulk ions, and the transit frequencies of resonant bulk ions are half EGAM frequency.

Summary

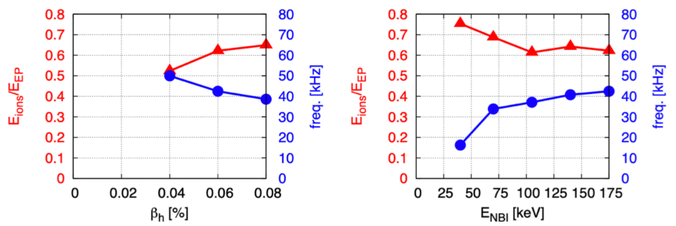
- The properties of EGAM channeling are systematically investigated for the first time.
- During the chirping EGAM activities, EGAM channeling occurs continuously in both linear stage and nonlinear stage; while in the non-chirping cases, EGAM channeling occurs only in the linear stage.
- Lower mode frequency makes higher energy transfer efficiency, because there is stronger interaction between lower frequency mode and bulk ions.
- The energy transfer efficiency does not change with temperature, because the ratio of f_{tr}/f_{EGAM} keeps constant.
- The energy transfer efficiency decreases with the increase of dissipation coefficient.
- The energy transfer efficiency of deuterium is less than that of hydrogen.

Energy Transfer and Growth Rate



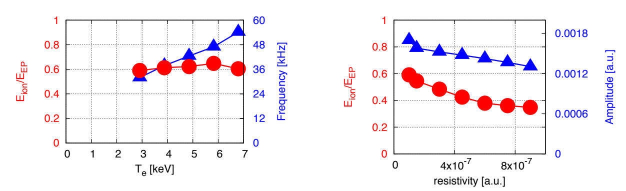
- Left: frequency chirps up as shown in the left column of poster.
- Right: frequency roughly keeps constant.
- During the chirping EGAM activities, EGAM channeling occurs continuously in both linear growth stage and nonlinear saturated stage; while during the non-chirping EGAM activities, EGAM channeling occurs in the linear growth stage but terminates in the nonlinear saturated stage.

Energy Transfer Efficiency: P_h and E_{NBI}



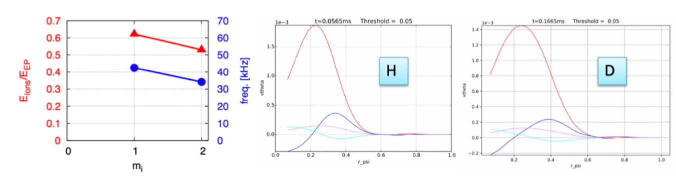
- The energy transfer efficiency increases with energetic particle pressure, but decreases with NBI velocity.
- Lower mode frequency makes higher energy transfer efficiency, because there is stronger interaction between lower frequency mode and bulk ions.

Energy transfer Efficiency: T and η



- The energy transfer efficiency does not change with temperature, because the ratio of f_{tr}/f_{EGAM} keeps constant.
- The energy transfer efficiency decreases with the increase of dissipation coefficient, because more energy dissipates by dissipation coefficient.

Isotope Effect



- The energy transfer efficiency of deuterium is less than that of hydrogen.
- The possible reason: orbit width is changed by the factor of 2, and thus, many basic properties are changed. Then, it is not appropriate to directly compare the energy transfer efficiency.
- The mode width becomes larger.