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The effect of plasma current on the current drive of electron cyclotron waves

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ABSTRACT

The effect of plasma current (I_p) on the current drive by EC waves is studied via numerical approach. It is found that changing of plasma current has a middle impact on ECCD but a large influence on the Ohkawa mechanism dominant current drive (OKCD). Increasing of plasma current makes the ECCD moves slowly into the core region of tokamak plasma, but makes the OKCD shifts rapidly into the edge region. The current drive efficiency increases slowly with the increasing of I_p for ECCD, but increases first then dropping for OKCD. These results may have some influence on the suppression of TMs/NTMs by ECCD or OKCD, and an important significance in the current ramp-up phase via LHCD and ECCD.

BACKGROUND

- Current drive by EC waves has an important role in tailoring plasma current profile and suppressing MHD instabilities.
- Plasma current in a tokamak, its amplitude I_p and profile, has a vital impact on LHCD.
- The plasma current I_p possibly has impacts on the ECCD and OKCD for deposition of EC power on HFS and LFS, respectively.
- This study is to analyze the role of plasma current I_p on current drive of EC waves for both the Fisch-Boozer and the Ohkawa dominated mechanism.

NUMERICAL SETUP

- A series of equilibrium files with different I_p are generated.
- HL-2M like tokamak, a/R ~ 0.37, B_{T0} = 2.25 T.
- 105 GHz (X2) EC for OKCD, 140 GHz (X2) EC for ECCD.
- The initial launch position of EC waves: (R_i,Z_i) = (2.45m,0.0m).
- Toroidal launching angle: a = 160°.
- The GENRAY/CQL3D codes are used in simulations.
- Kinetic profiles are shown in Fig. 1.

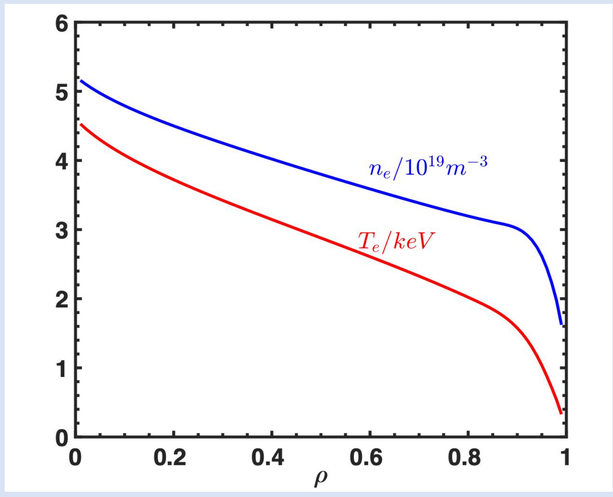

Fig. 1 Profiles of n_e and T_e.

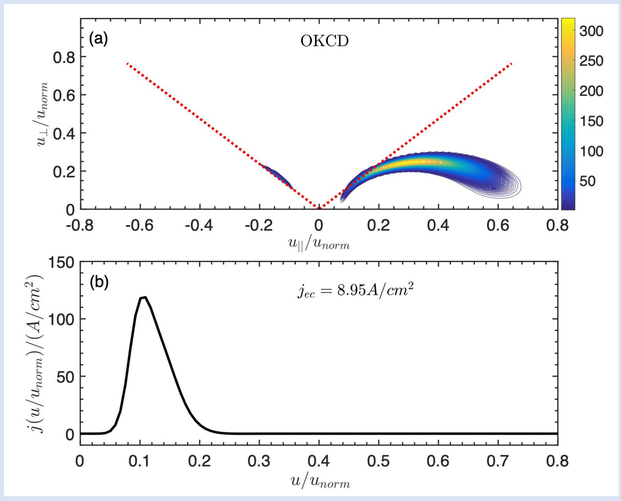

Fig. 3 OKCD at ρ = 0.69.

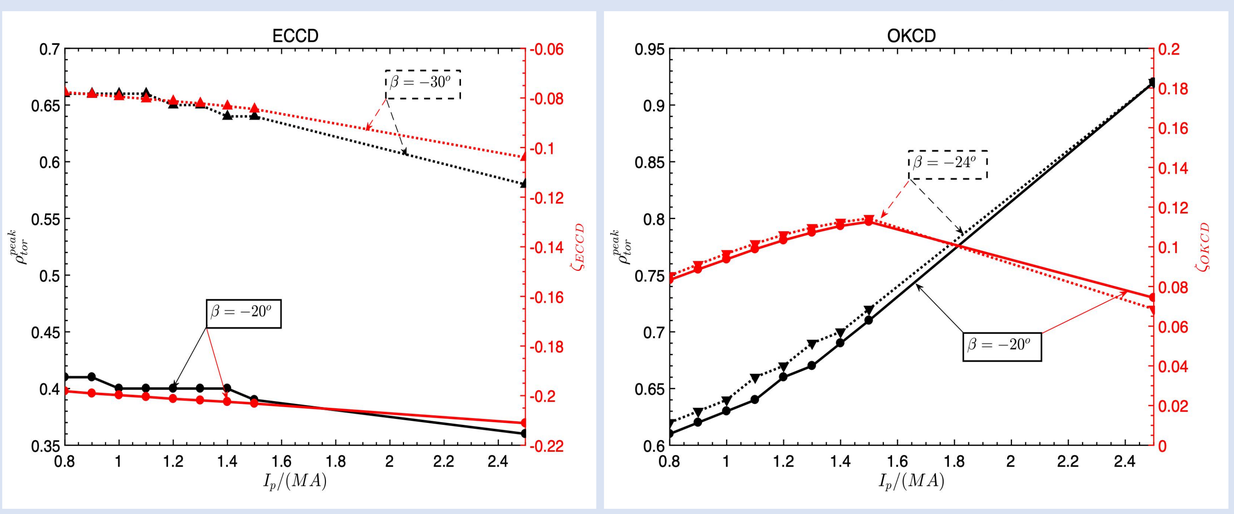

Fig. 2 Effect of I_p on ECCD (left) and OKCD (right)

RESULTS

- **Effect of I_p on ECCD:**

  1) with the increasing of I_p, the normalized radius position at peak current ρ_{tor}^{peak} decreases very slowly, the normalized current drive efficiency ζ_{ECCD} increases slowly .(Fig.2 (left))

RESULTS (Continue)

- **Effect of I_p on ECCD:**

  2) I_p has little impact on current drive width δ_{cd} for on-axis ECCD, but larger I_p makes wider δ_{cd} for off-axis ECCD. (Fig.5)

  3) I_p has little influence on the peak vale of ECCD. (Fig.5 (right))

  4) Fig. 4 shows how a Fisch-Boozer dominated current is generated in velocity space.

- **Effect of I_p on OKCD:**

  1) With the increasing of I_p, ρ_{tor}^{peak} increases rapidly, ζ_{OKCD} increases slowly then drops. (Fig. 2 (right))

  2) Larger I_p makes wider δ_{cd} for OKCD. (Fig.5 (left))

  3) The peak vale of OKCD decreases largely as the increasing of I_p.

  4) Fig. 3 shows how the Ohkawa mechanism generates the dominant current in velocity space.

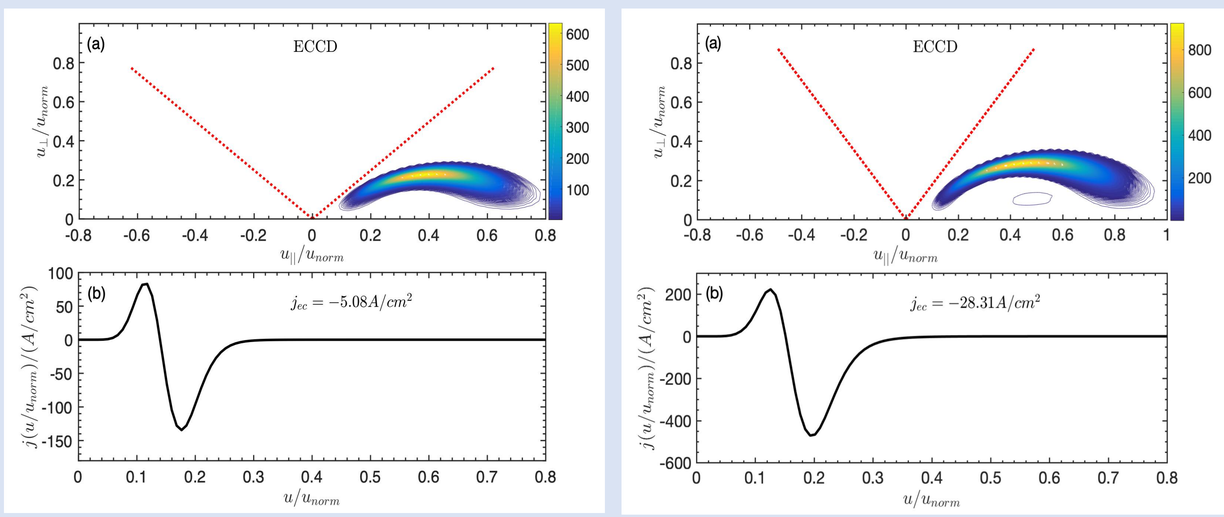

Fig. 4 ECCD at two different location. ρ = 0.64 (left), ρ = 0.36 (right).

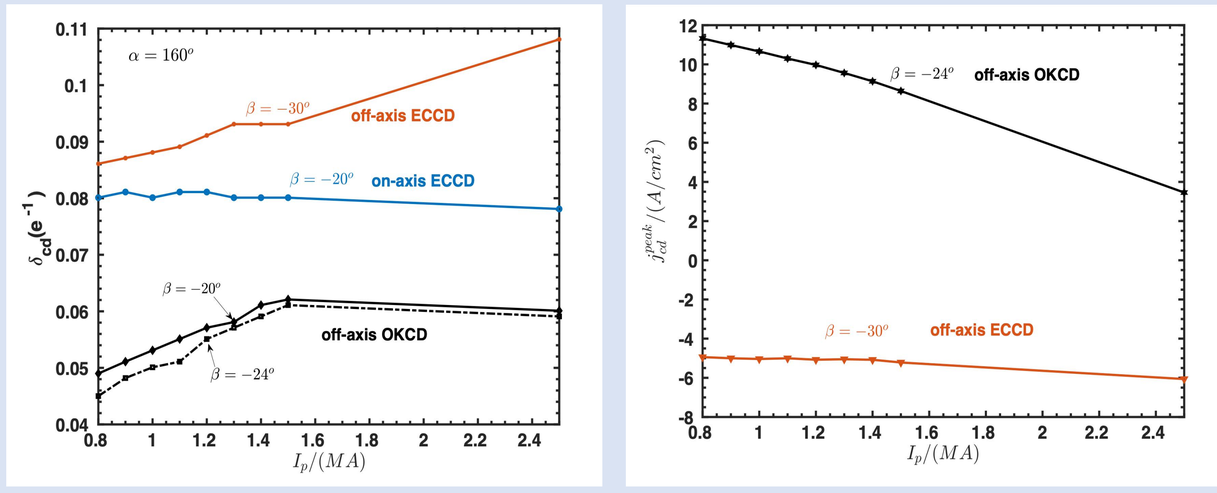

Fig. 5 Effect of I_p on full width (e^{-1}) of driven current profiles (left), and peak value of current density (right).

CONCLUSION

- Plasma current I_p has a middle impact on ECCD but a large influence on OKCD.
- According to this simulation, we speculate that the existence of a TM/NTM magnetic island may not affect the propagation of EC waves, nor do it affect the radial position of ECCD/OKCD, especially for the case of HFS deposited ECCD, but it may widen the current profile of ECCD/OKCD.
- The finds may have an important significance in the current ramp-up phase via LHCD and ECCD when EC wave power is deposited on LFS.

ACKNOWLEDGEMENTS / REFERENCES

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