EBW-Bootstrap Current Synergy in NSTX

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NSTX Results Review, Sept 20-21, 2004

- EBW presents near ideal conditions for enhanced BSCD by RF induced pitch angle scattering, particularly in Spherical Tori

- A kinetic calculation of bootstrap current combining collisions and EBW QL diffusion is given below, using a simplified BS model in the CQL3D Fokker-Planck code

- The model is validated against standard BS results

- Application is made to an NSTX 40% beta equilibrium

Bootstrap Current Model, and Validation

Simple model of bootstrap based on physical picture:

- At each radius there is a net magnetization current: co-current producing particles have average position one-half banana width inwards, whereas counter current producing particles have average position shifted outwards ==> (due to density gradients)

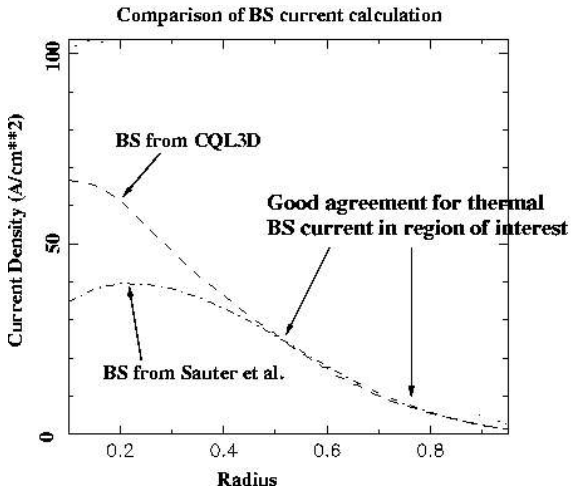
$$j_{banana} = -ev_{\|}(\Delta_{banana}\frac{dn_{trap}}{d\rho}) = -\frac{\varepsilon^{3/2}}{B_{pol}}\frac{dp}{d\rho}$$

- Detrapping of the plasma particles (collisions, rf) ==> source in transitting particles, amplifying j_{banana} to give bootstrap current

$$j_{bootstrap} = -\frac{\varepsilon^{1/2}}{B_{pol}}\frac{dp}{d\rho}$$

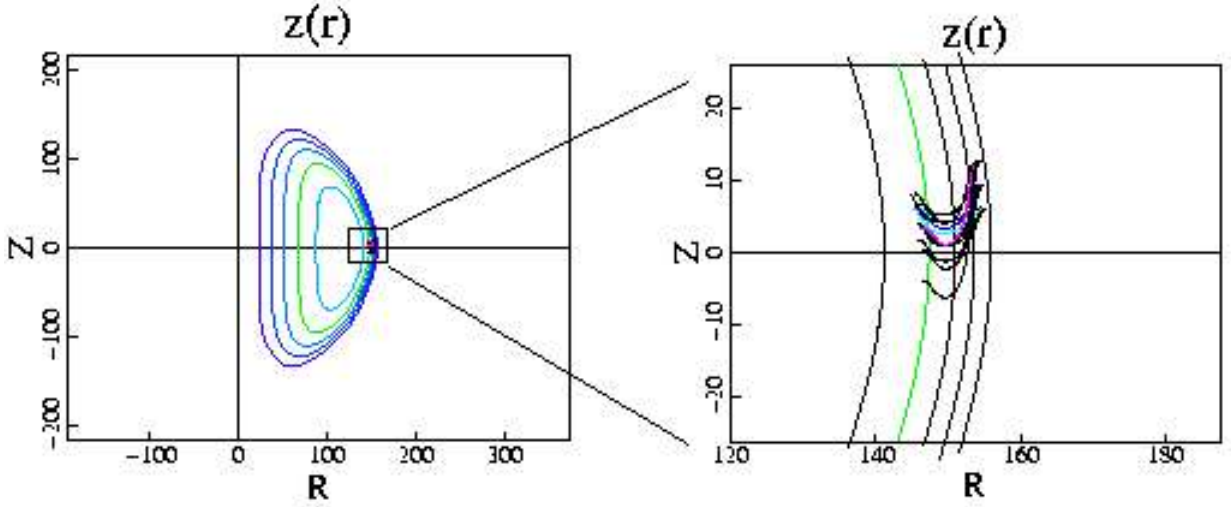
- The CQL3D Fokker-Planck code (otherwise zero-banana) implements this model by connecting co/counter-current passing particles to trapped particles displaced 1/2 banana inwards/outwards.

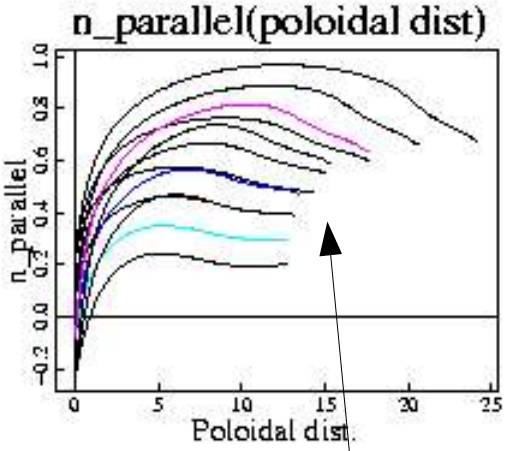
Validation of simplified kinetic model of BS current:



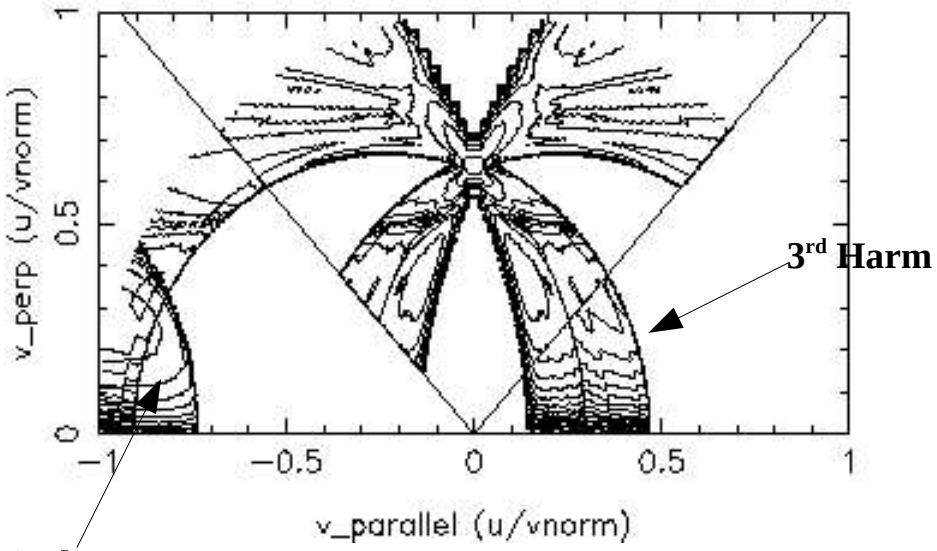
CQL3D and accurate Sauter (PoP,'99) results agree well over outer half of ST. (Inside eps=0.3, Westerhof (CPC, '96) found refinements again giving good agreement.)

EBW Rays in NSTX and Resulting QL Diffusion



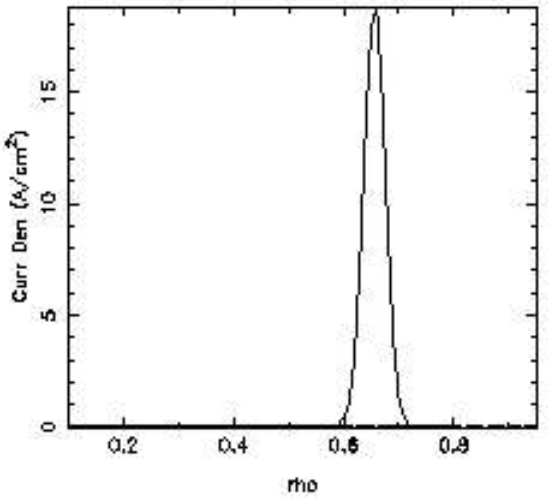


3rd Harm absorp



3rd Harm

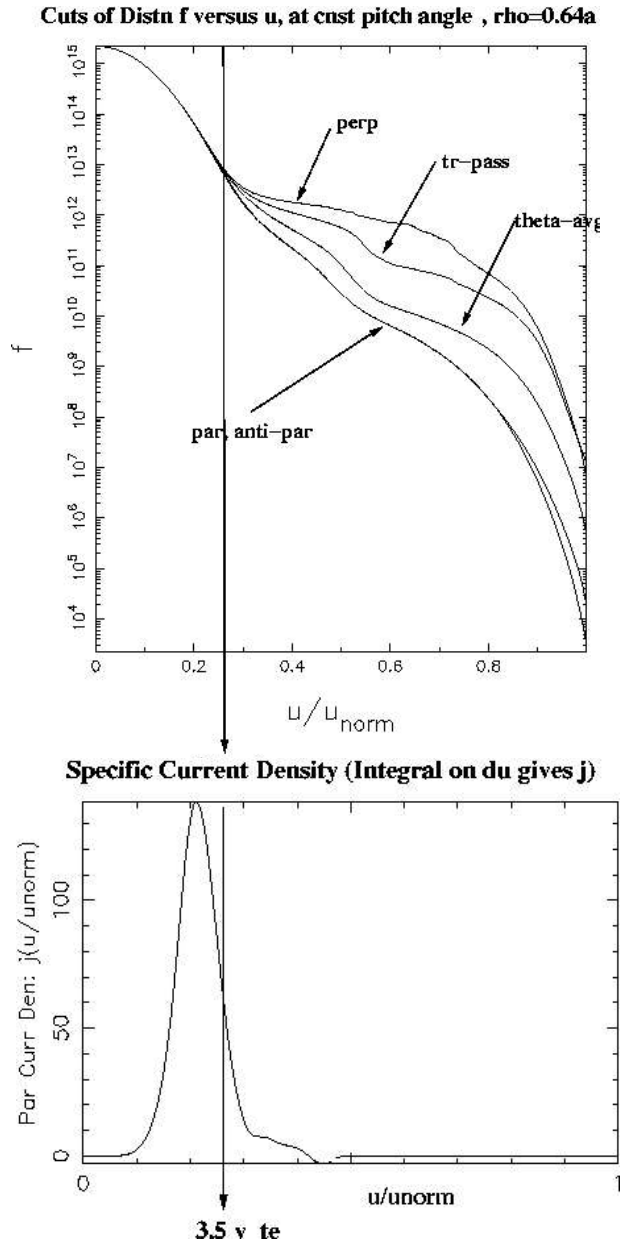
2nd Harm

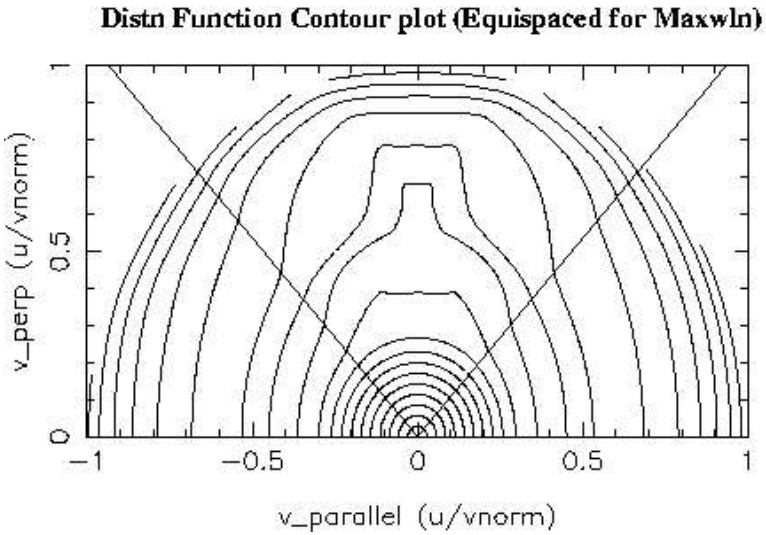


Positive current j is due to the Ohkawa CD effect.

COMPX

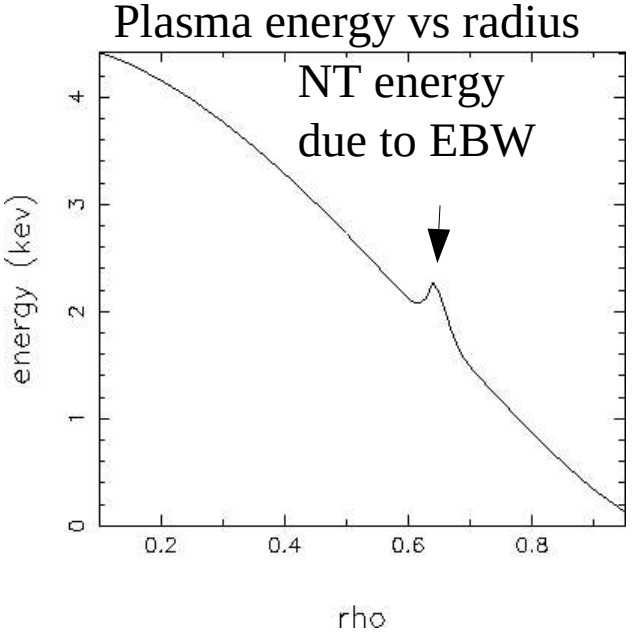
EBWCD, 1MW, Bootstrap Model Off

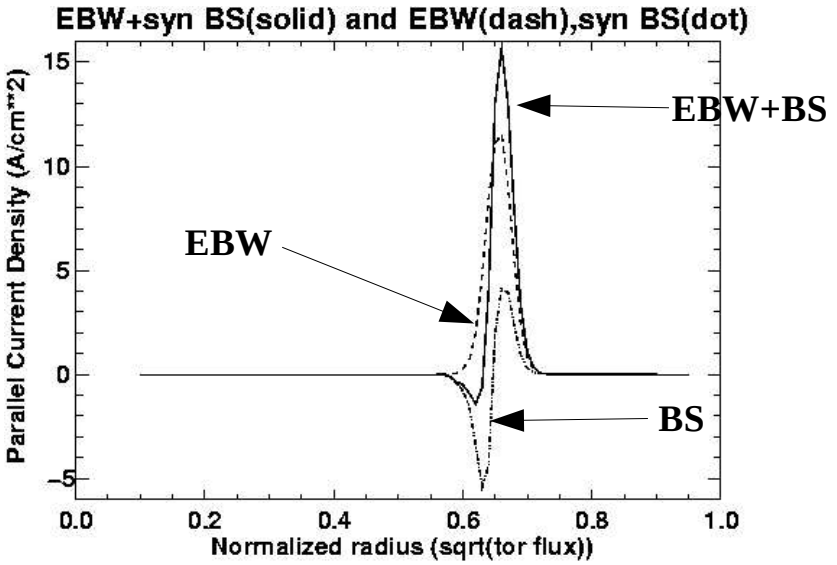




- Ninety percent of the EBWCD is in the near-Maxwellian region at v < 3.5 v_te.
- Collisions dominate the RF.
- No substantial EBW Synergy at this RF level (and plasma density).

1MW EBW, Bootstrap Model On





- Enhanced RF pitch angle scattering would yield BS current which is symmetric about the RF heating region.
- A this 1 MW level, BS current is anti-symmetric, therefore due to the locally enhanced plasma pressure.
- (At 4 MW, 10% symmetric increase in net BS current is obtained.)

Conclusions

- A 40% beta NSTX discharge has been investigated computationally for evidence of BSCD due to EBW enhanced pitch angle scattering.
- The effect of RF pitch angle scattering on BS current is small (< 10%), for up to 4 MW of EBW power.
- When there is a localized enhancement of plasma pressure due to EBW heating, anti-symmetric BS will be excited. But this depends on heat transport.
- **POSTSCRIPT:** The EBWCD reported here is Ohkawa CD. In principle, the enhanced trapping gives, in the neoclassical transport picture, a particle pinch and a compensating BSCD due to the modified n_e-profile. (But particle transport is not well understood.)