DEPENDENCE OF ECH WAVE-INDUCED SCATTERING RATES ON THE ELECTRON DISTRIBUTION

Magnetospheric formation processes of the diffuse aurora

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Introduction

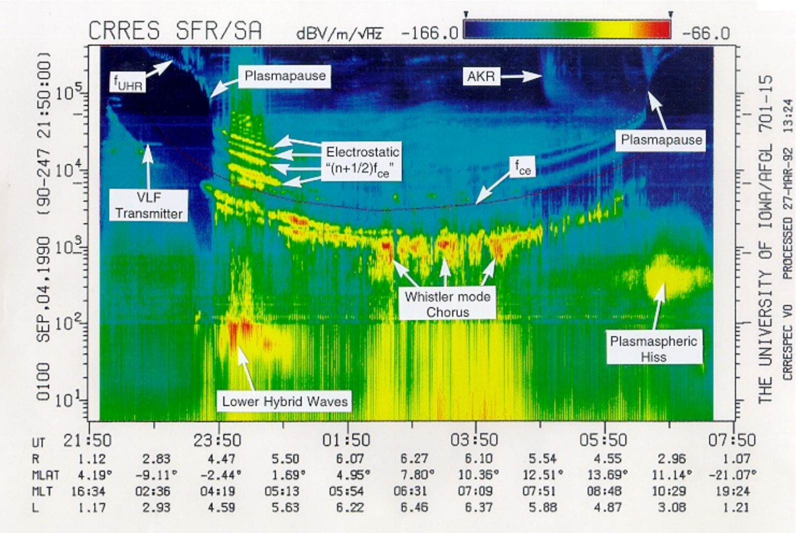
- Resonant wave-particle interactions:
  $\omega - k_{||} v_{||} = \frac{n\Omega_\sigma}{\gamma}, \Omega_\sigma = \frac{|q|B}{mc}$

- Violation of the 1st adiabatic invariant by plasma waves $\Rightarrow$ Pitch-angle scattering into the loss cone and precipitation

- Precipitating electrons with energies of 0.1 to 10s of keV can produce diffuse aurora

Image courtesy of the Earth Science and Remote Sensing Unit, NASA Johnson Space Center

Electrostatic electron cyclotron harmonic waves



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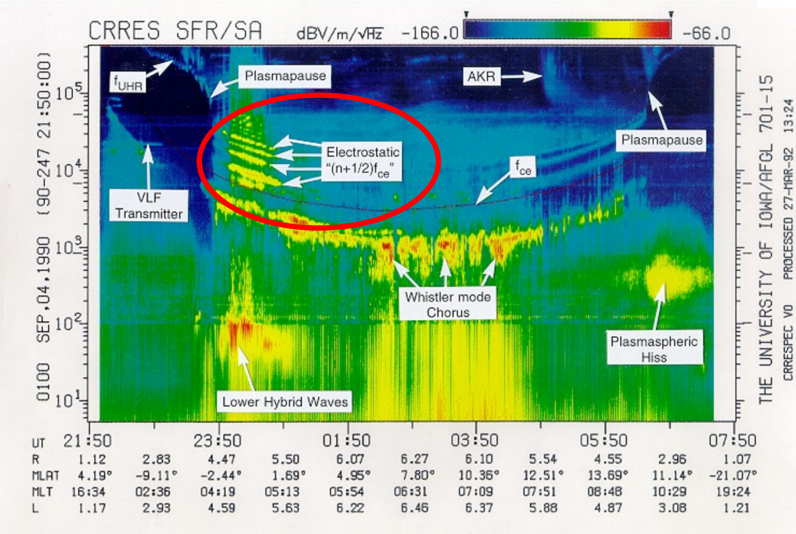

Calculation of ECH wave-induced diffusion coefficients

- Use WHAMP and Full Diffusion Code to calculate bounce-averaged momentum and pitch angle diffusion coefficients (Ni et al., 2008; Shprits and Ni, 2009)
- Solve the hot plasma dispersion relation along with the resonance condition
- Depends on:
  - Wave power spectrum
  - Wave normal angle distribution
  - Number of resonances
  - Background magnetic field
  - Plasma density
  - Properties of the hot plasma sheet electrons responsible for wave excitation

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Calculation of ECH wave-induced diffusion coefficients

Model the electron distribution by (Ashour-Abdalla & Kennel, 1978)

$$f(v_\perp, v_\parallel) = \sum_{i=1}^{m} \frac{n_i}{\pi^{3/2} a_{\perp,i}^2 a_{\parallel,i}} \exp\left(-\frac{v_\parallel^2}{a_{\parallel,i}^2}\right) \cdot \left\{ \Delta_i \exp\left(-\frac{v_\perp^2}{a_{\perp,i}^2}\right) + \frac{1-\Delta_i}{1-\beta_i} \left[\exp\left(-\frac{v_\perp^2}{a_{\perp,i}^2}\right) - \exp\left(-\frac{v_\perp^2}{\beta_i a_{\perp,i}^2}\right) \right] \right\}$$

with electron density n_i, loss cone parameters Δ_i and β_i, and perpendicular and parallel thermal velocity $a_{\perp,i}$ and $a_{\parallel,i}$ (related to plasma temperature)

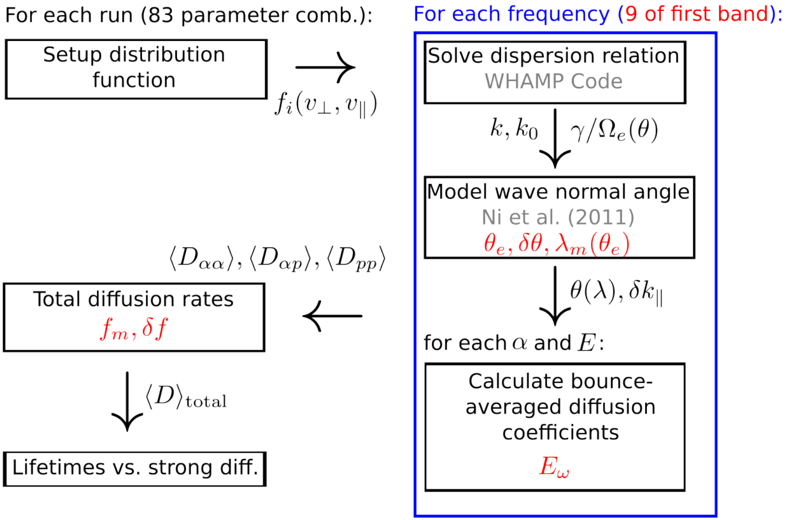
Parameters of the electron distribution

Model electron distribution with one cold and one hot plasma component

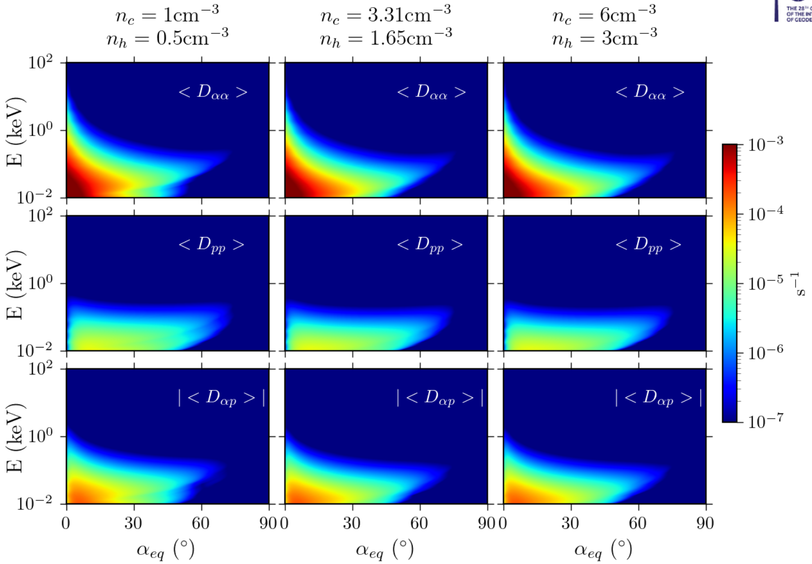
Component	$T_\perp$ (eV)	$T_\parallel$ (eV)	n (cm^{-3})	Δ	β
1 (cold)	1	1	3.31	1	-
2 (hot)	621	621	1.65	0.5	0.02
range of variation					
1 (cold)	-	-	1 to 6	-	-
2 (hot)	100 to 10000	100 to 10000	0.5 to 3	0.3 to 0.9	0.01 to 0.4

based on Horne and Thorne (2000), Ni et al. (2011), Fukizawa et al. (2020), Lou et al. (2022)

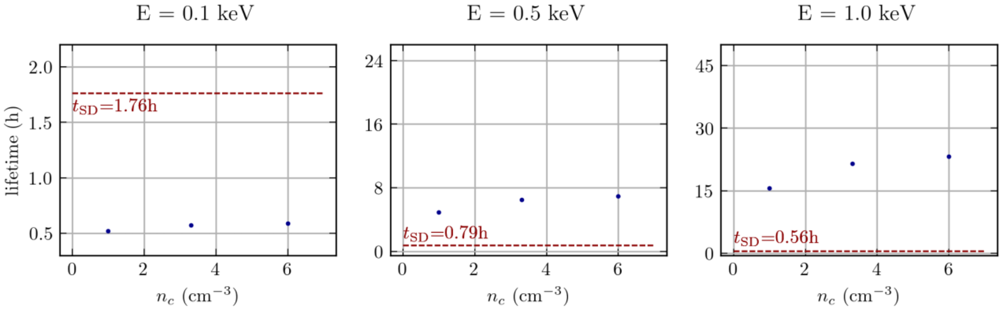
Calculation of ECH wave-induced diffusion coefficients



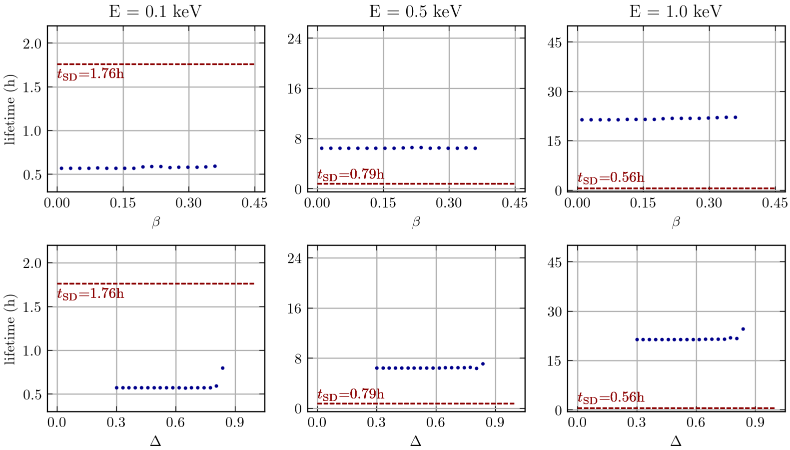
Variation of diffusion coefficients with plasma density



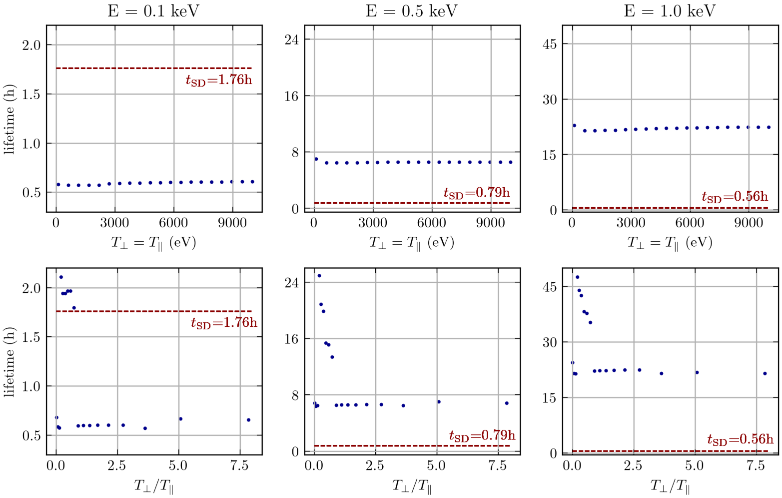
Variation of electron lifetimes with plasma density



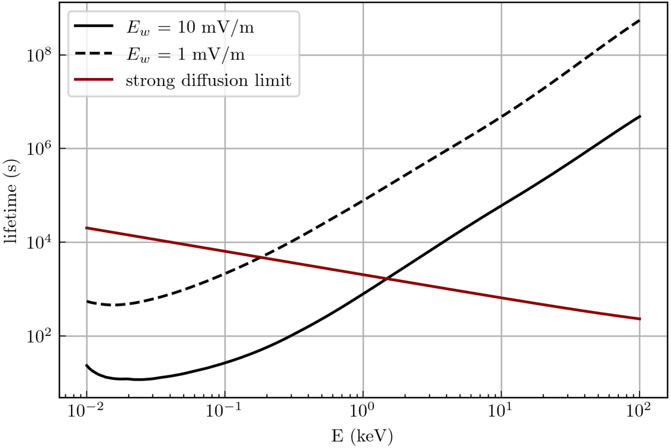
Variation of electron lifetimes with loss cone parameters



Variation of electron lifetimes with hot plasma temperature



Variation of lifetime with wave amplitude



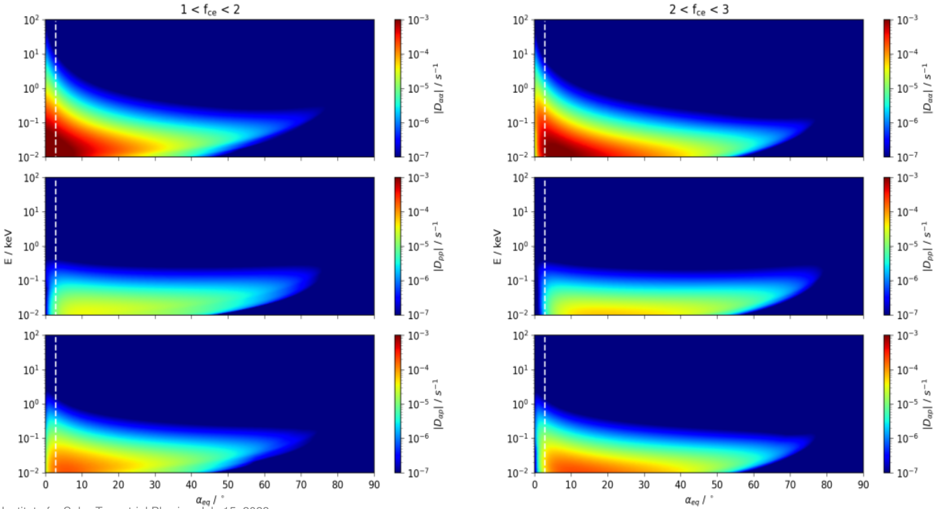
Summary and conclusions

- Pitch angle scattering by ECH waves significantly contributes to diffuse auroral precipitation of electrons with energies of a few hundred eV
- During disturbed conditions, lifetimes can become comparable to the strong diffusion limit for electron energies up to several keV
- Plasma density and temperature anisotropy influence the loss of electrons

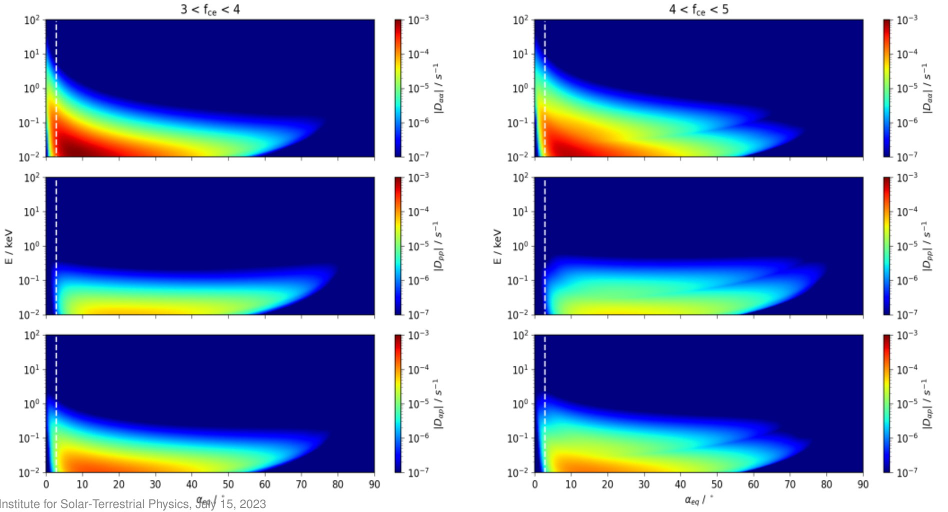
Outlook

- Calculate event-specific diffusion coefficients
- Implement diffusion coefficients in codes for radiation belt dynamics

Second harmonic band



Third and fourth harmonic bands



Growth rate vs. wave normal angle