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New models of AKR beaming and fine structure derived from Cluster WBD observations

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We present new results on several long-standing problems in AKR research: the origin of fine structure, the relationship between observed AKR intensities and in situ electron distribution functions, and the angular beaming properties of AKR. We computed the growth rates and emergent intensities associated with X and O-mode radiation from the cyclotron maser instability as a function of the ambient electron velocity distribution and k-vector orientation using an analytic horseshoe velocity distribution closely fitted to FAST observations of energetic electron distributions in the auroral cavity. The growth rate is sharply peaked at perpendicular propagation ($k_{\|} = 0$). The maximum observed intensities ($\sim 10^{-4}\ V^2 m^{-2} Hz^{-1}$) are obtained with convective growth lengths 20-40 km at perpendicular propagation. Perturbation of the velocity distribution by small-scale ion solitary structures (ISS), closely matched to observed ISS profiles, can enhance the emergent intensity by 40-50 dB, consistent with observed AKR fine structure. This may also apply to electromagnetic ion-cyclotron waves, but not to electron holes, which always diminish growth rates.

We also used the Cluster WBD system in VLBI mode to determine the beaming patterns of more than 11,000 terrestrial AKR bursts. By combining the locations of AKR bursts with the known spacecraft locations, we show that the angular beaming pattern is closely confined ($\sim 10^o$) to a ’tangent plane’ containing the local magnetic field direction and tangent to the auroral oval, consistent with numerical models of AKR generation.