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Auroral Kilometric Radiation -Horseshoe Model and Experiment

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AKR is a powerful phenomenon of producing cyclotron maser emission from polar regions and it is common for many astrophysical sources with strong magnetic field, including the Earth. We claim that a horseshoe-shape distribution of electrons in momentum space is a drive for such emissions. This distribution forms when a beam of electrons moves into convergent magnetic field. We did theoretical modelling, numerical simulations and scaled laboratory experiment modelling formation of such a distribution and radiation from it by mechanism of cyclotron maser emission with perpendicular drive.

The shape of the distribution has a good resemble with electron momentum distributions from several satellite observations data taken inside the source. Predicted frequency from theory and numerical simulations is in very good agreement with the experiment and the observations for the Earth's AKR. As with the observations, the radiation was found to come almost perpendicularly to the electrons' motion. The distribution proved to be unstable to cyclotron instability, providing a much higher growth rate then a loss cone distribution which is often used for modelling this radiation. Numerical simulations and theory were accurate in predicting the power of radiation and its polarisation for the experiment where a high power radiation from magnetically confined distribution was observed at a frequency just under the cyclotron frequency, being polarised in TE mode which corresponds to X-mode in auroral cavities.

Addressing the recent observational results which discovered that the emission at a source comes out at a small angle to the perpendicular to the magnetic field/electron beam motion, in a direction slightly towards the opposite direction to that of the electrons motion, we checked that with our model, numerical simulations and the experiment. They all confirmed the direction of propagation at about 40 backward from the perpendicular direction with respect to the electrons motion. Our additional theoretical analysis showed that the backward propagation is a universal feature for this kind of emission and does not only happen for some particular range of parameters.

The theory, simulations and experiment, all showing very good agreement with all the details of observations, strongly support the hypothesis that the horseshoe distribution drives AKR and similar emissions from astrophysical sources. We plan to apply this model forcyclotron emission also to extrasolar objects producing radio emission.