Holistic simulations of Ionospheric Radio Heating Experiments

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Abstract:

Ionospheric radio heating experiments can be used to study plasma-wave interactions in parameter regimes not easily accessible in laboratories[1]. Specifically the ionospheric plasma density varies very slowly in space (over several 10s of km) compared to the wavelength of electromagnetic waves (~100 m) used in heating experiments. Additionally the ionosphere is a photo-ionised plasma which is therefore relatively cool compared to laboratory plasmas. In the past few decades experiments conducted at installations such as the High Frequency Active Auroral Research Program (HAARP) in Alaska and at the Tromsø heater in Norway run by the European Incoherent Scatter Scientific Association (EISCAT) have demonstrated increasingly pronounced effects as transmitter powers have increased[2]. This includes production of plasma turbulence and artificial enhancement of the ionospheric plasma density near the reflection point where the input frequency equals the local plasma frequency. Attempts to simulate computationally the behaviour of the ionospheric plasma during such experiments are complicated by the differences in length and time scales between the input HF radio wave, the ionospheric density profile and the centimetre scale turbulence excited. Most prior research has focused on local simulations of turbulence (typically using electrostatic models), whilst the electromagnetic wave propagation has been modelled separately via methods such as ray tracing[3]. Recently, however, attempts have been made to simulate the entire problem in a holistic fashion[4]. This paper will describe developments of this holistic approach. Whilst the models are still constrained (limited dimensionality and use of a relatively simple model of the plasma behaviour) they do represent the self-consistent coupling between electrostatic plasma oscillations and the electromagnetic fields. This approach offers new possibilities in understanding and interpreting the experiments. Such research contributes to broader understanding of plasma-wave interactions with applications for plasma modification. This presentation will describe the simulation models and preliminary results.

References:

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