Solar Radio Bursts and the Prediction of Space Weather at Earth

IVER H. CAIRNS

School of Physics, University of Sydney, NSW 2006, Australia

Solar radio bursts at metric and longer wavelengths were discovered over 50 years ago and rapidly interpreted in terms of coherent radiation produced near the electron plasma frequency f_p and near $2f_p$ by energetic electrons accelerated in solar flares (type III bursts) and by shocks (type II bursts). The radio bursts are associated with coronal mass ejections (CMEs), X-ray events, and acceleration of solar energetic particles (SEPs) that all produce space weather events at Earth. It has long been recognized that the combination of robust observational characterization of the radio emissions and the development of detailed data-tested theories has great potential for predicting space weather events at Earth with long lead time and for inferring the properties of the corona. This Lecture will demonstrate the great progress made in recent years towards realizing this potential. Specifically, it will: (1) describe the new Automatic Radio Burst Identification System (ARBIS) that is operational with IPS Radio & Space Services, robustly identifying type II and III bursts in Australian radio telescope data; (2) summarize a recent cradle-to-grave theory for type II bursts and associated 2D modeling of the interplanetary plasma, and demonstrate that they yield quantitative dynamic spectra that agree quite well with some well-defined observed type II events; (3) present iterative data-theory comparisons that illustrate the potential for real-time extraction of a shock's 3-D velocity and locus, plus refinable prediction of the arrival time at Earth; and (4) show that novel analyses of coronal type II and III bursts yield coronal density profiles that are much more gentle than expected on the basis of power-law fits to eclipse and coronagraph data, and are consistent with wind-like outflow from localized sources close to the photosphere. Unresolved issues and future research directions will also be sketched.

Keywords: Solar radio bursts; space weather; coronal mass ejection; ARBIS; shocks; electron acceleration; plasma waves; radio emissions; coronal density profiles; origin of the solar wind.