WG1/WG3: Radio Observations of CMEs and Particle Acceleration

Working Groups 1 and 3 held a joint session on radio observations of CMEs and particle acceleration. This is a new topic for the SHINE workshops, so the intent of this half-day session was to introduce the topic with invited talks from experts in the field. The questions to be addressed at the workshop included:

1. What can radio observations tell us about CMEs in the low corona – structure, dynamics, and magnetic field?
2. What can radio observations tell us about particle acceleration associated with CMEs in the low corona – location, timing, and mechanism?
3. How do radio observations fit with observations of CMEs at other wavelengths – visible, EUV, X-ray?

Tim Bastian (NRAO) opened the session with a talk on radio emission from CME structures in the low corona. He showed that both thermal (free-free) and non-thermal (synchrotron) emission has been observed from CMEs. In one case (April 20, 1998), loops observed in radio emission compared fit well on a height-time curve of a CME from LASCO observations. Observations of synchrotron emission from this and other CMEs have provided estimates of CME densities (a few times 10^{-7} cm^{-3} at 1.45 Rs) and magnetic field strengths (about 1.5 G at 1.45 Rs). In another case (April 15, 2001) an electron transport model was used to infer the injection spectrum at the Sun from ACE observations of energetic electrons at 1 AU. The injection spectrum is a good match to the integrated profile of radio flux from Nancay Radioheliograph observations. This talk also highlighted the utility of radio observations for observing the nascent stages of CME evolution with high temporal cadence, and without the need for an occulting disk as in a visible-light coronagraph.

Stephen White (University of Maryland) gave a tutorial on the various types of radio bursts and how to identify them on dynamic spectra. He argued that metric type II bursts are a flare phenomenon and are not CME-driven. Among the reasons for this conclusion were that type II bursts never occur without flares, but they do occur without CMEs, and that when they occur with both flares and CMEs, the burst always lies at a lower altitude than the corresponding CME. He also brought the audience up-to-date on the Green Bank Solar Radio Burst Spectrometer. This is a new facility that is obtaining dynamic spectra of radio bursts, and is the only facility of this kind in a Western hemisphere (North and South America) time zone.

Hilary Cane (University of Tasmania and NASA/GSFC) discussed the relationship between solar radio emissions and energetic particle events. She argued that major proton events are better associated with long-lasting type III bursts (type III-l) than with type II bursts. Since type III bursts are caused by electrons streaming along open field lines, this implies that there must be open field lines from the low corona (< 2 Rs) associated with major SEP events. She also argued that metric type II bursts are unlikely to be caused by CME-driven shocks, since one can almost never draw a smooth curve between metric and kilometric type II bursts on a dynamic spectrum.

Michael Reiner (Catholic University and NASA/GSFC) also discussed the relationship between solar radio observations and energetic particle events. He pointed out that simple type III bursts are associated with moderate solar flares, while complex type III bursts (Cane's type III-l) are more typically associated with large flares and CMEs. These complex events often involve multiple electron injections, multiple acceleration sites, large-scale coronal reconfigurations, and multiple propagation channels to the interplanetary medium. The electrons that are responsible for the complex type III bursts are accelerated deep in the corona and propagate outward on open field lines. He also posed a question as to whether radio observations could provide information on ion acceleration processes as well as electron acceleration. He showed an intriguing timing analysis that suggested a coincidence between proton injection and electron acceleration in the Bastille Day 2000 CME event.