# Study Galactic Cosmic Ray Modulation in the Global Heliosphere

Xi Luo

To understand the behavior of cosmic ray modulation seen by two Voyager spacecraft in the region near termination shock (TS) and heliosheath at distances of $>\sim 100$ AU, a realistic MagnetoHydroDynamic (MHD) global heliosphere model is incorporated into the cosmic ray transport code, so that the detailed effects of heliospheric boundaries and its plasma/magnetic geometry can be revealed. A number of simulations of cosmic ray modulation with this code reach the following conclusions. (1) Diffusive shock acceleration (DSA) by the TS can significantly affect the level of cosmic ray flux and in particular its radial gradient profile in the region near the TS and in the inner heliosheath. The shock acceleration effect can be easily lost if the TS is unrealistically smoothed due to a lack of spatial resolution in some previous MHD simulations. (2) The radial profile of cosmic ray flux strongly depends on longitude. There is a slight North-South asymmetry due to an asymmetric TS, but more difference of radial profile comes from the longitudinal effect. Voyager 1 and 2 are separated by $\sim 40^\circ$ in longitude. Simulations in these directions show large difference in the radial profile of cosmic ray flux that can prevent meaningful determination of cosmic ray radial gradient from Voyager measurement. Various other simulations are also performed to show how particle diffusion coefficient, cosmic ray energy, and interstellar spectrum can affect cosmic ray transport.

I also conducted the studies about the effect of Global Merged Interaction Region (GMIR) on cosmic ray transport in the heliosheath. A GMIR model with intensified magnetic field and increased solar wind speed is constructed and incorporated into the cosmic ray transport code. The simulation reproduces decrease of cosmic ray flux upon the arrival of the GMIR at the spacecraft, consistent with previous simulation performed for inner region of the supersonic solar wind. However, as the simulation location is moved outside of the TS, it shows a new feature. Cosmic ray flux begins to decrease as the GMIR arrives at TS, which can be months prior to the GMIR arrival at

the spacecraft. Spacecraft inside the heliosheath, such as Voyager 1, can remotely sense the time when the GMIR arrives at TS. Based on this remote sensing feature, the radial distance of the TS along the Voyager 1 direction is estimated to be about 91AU in 2006, a value agrees well with Voyager observation of an inward propagating North-South asymmetric TS.