Finite Larmor radius effect on the cosmic ray density distribution inside an interplanetary magnetic flux rope

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Sudden decreases in cosmic ray intensity during geomagnetic storms are well known as Forbush decreases. Observations of cosmic rays by neutron monitors and muon detectors revealed that Forbush decreases are caused by the passage of interplanetary shock waves with downstream highly turbulent magnetic fields and by magnetic clouds (flux ropes) that have well-ordered strong magnetic fields. A mechanism of cosmic ray penetration into an interplanetary magnetic flux rope is not well understood and it is interesting topic to research. All previous studies for cosmic ray penetration into an interplanetary magnetic flux rope only considered guiding center motion and ignored the gyration of cosmic ray particles, namely, the Larmor radius of the cosmic ray particle is assumed to be infinitely small compared with the flux rope radius. However, in the case of high-rigidity cosmic rays inside an interplanetary magnetic flux rope, the assumption is not always valid. Therefore, we should examine the effect of a finite Larmor radius on cosmic ray penetration into an interplanetary magnetic flux rope. In this presentation, we discuss a mechanism for cosmic ray penetration into an interplanetary magnetic flux rope, particularly the effect of the finite Larmor radius and magnetic field irregularities. We perform a numerical simulation of a cosmic ray penetration into an interplanetary magnetic flux rope by adding small-scale magnetic field irregularities. This simulation shows that a cosmic ray density distribution is greatly different from that deduced from a guiding center approximation because of the effect of the finite Larmor radius and magnetic field irregularities for the case of a moderate to large Larmor radius compared to the flux rope radius.