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チベット空気シャワーアレイで観測された10TeV宇宙線中の「太陽の影」による太陽コロナ磁場の診断
Probing solar coronal fields using the Sun's shadow in cosmic ray intensity observed with the Tibet air shower array

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Very high energy cosmic rays travel nearly straight in the interplanetary space between the Sun and the Earth. The Sun shields these particles and casts a tiny shadow in the cosmic ray intensity measured at the Earth, so-called the "Sun's shadow". We continuously observed the Sun's shadow in 10 TeV cosmic ray intensity with the Tibet air shower array over an entire period of the Solar Cycle 23. We find a good correlation between the intensity deficit in the Sun's shadow and the solar activity changing with the 11-year cycle. The intensity deficit decreases (increases) in the solar activity maximum (minimum) period. In this paper, we present a variation of the Sun's shadow observed in a period from 1996 through 2009 and discuss the effect of the large-scale structure of the coronal magnetic field on the shadow by means of numerical simulations. We calculate trajectories of antiparticles ejected from the Earth to the Sun in the model magnetic field and reproduce the Sun's shadow. For the magnetic field in the solar corona, we adopt the PFSS (Potential Field Source Surface) and CSSS (Current Sheet Source Surface) models and examine which model can reproduce better the observed Sun's shadow. The PFSS model ignores effects of the electric current in the solar corona, while the CSSS model takes account of the large-scale horizontal and volume currents. The large-scale magnetic field structures derived from two models are significantly different. We find that the intensity deficit in the simulated Sun's shadow is very sensitive to the coronal field structure. It is clear from the statistical consideration that the Sun's shadow observed by the Tibet air shower array is better reproduced by the CSSS model than by the PFSS model. The Tibet air shower experiment succeeded for the first time in evaluating the coronal field models by using the Sun's shadow observed in the very high energy cosmic ray intensity.

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