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Using magnetic ray-tracing to reproduce the Sun's cosmic-ray shadow as seen by IceCube

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The cosmic-ray Sun shadow is caused by high-energy charged cosmic rays (CRs) being blocked and deflected by the Sun and its magnetic field, thereby modulating the resulting shadow in both size and shape. Recent Sun shadow observations by ground-based particle observatories have established a novel and potentially fruitful link between solar physics and high-energy particle astrophysics. Most notably, the shadow's size and depth was recently shown to correlate with the 11-year solar cycle.
This talk addresses the observational situation, the general setup and implementation of our group's Sun shadow simulations, test cases, and actual simulations of increasing complexity. Based on extrapolations from magnetograms, we create artificial shadow images by numerically computing trajectories of charged CRs in the coronal magnetic field for the energy range of 5-316 TeV and for various mass numbers and typically measured CR spectra, and analyze these images in comparison to data from the IceCube neutrino observatory. We confirm the observationally established correlation between the magnitude of the shadowing effect and both the mean sunspot number and the polarity of the magnetic field during the solar cycle. Contrary to previous findings, a non-monotonous dependence on energy during solar minimum is identified and modeled using a simplified (dipolar) configuration for the coronal magnetic field.

Keywords

particle tracing, imaging, solar corona, magnetic field

Collaboration

other Collaboration

Subcategory

Theoretical Results

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