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Probing atmospheric electric fields in thunderstorms through radio emission from extensive air showers

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Energetic cosmic rays impinging on the atmosphere create a particle avalanche called an extensive air shower. In the leading plasma of this shower electric currents are induced that generate radio waves which have been detected with LOFAR, a large array of simple antennas primarily developed for radio-astronomical observations.

LOFAR has observed air showers under fair-weather conditions as well as under atmospheric conditions where thunderstorms occur. For air showers under fair-weather conditions the intensity as well as the polarization of the radio emission can be reproduced rather accurately by the standard model using a superposition of a geomagnetically-induced transverse current and a charge-excess contribution.

For air showers measured under thunderstorm conditions we observe large differences in the intensity and polarization patterns from the fair weather model. We observe for these showers that it is not possible to get a good fit of the measured intensity pattern. For the same air showers the dominant polarization direction differs from the orientation observed in the fair-weather condition.

We show that this difference is a consequence of atmospheric electric fields. We also show that the basic effects of atmospheric electric fields on radio emission from air showers are understood. Therefore, measuring radio emission from extensive air showers during thunderstorm conditions provides a new tool to probe the atmospheric electric fields present in thunderclouds.

Collaboration

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