

# Magnetic field generation by the first cosmic rays

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## What is this contribution about?

The origins of magnetic fields and cosmic rays are long standing problems in astrophysics. In this work, we consider magnetic field generations by the first cosmic rays.

## Why is it relevant / interesting?

Naively, CRs are expected to be accelerated after large-scale magnetic fields are generated and amplified. We recently proposed that the first CRs are accelerated before the large scale magnetic field generation. Since CRs are expected to amplify the magnetic field in the current universe, we can expect a magnetic field generation by the first CRs in the early universe.

## What have we done?

We have considered effects of the electron return current on the magnetic field generation. We have performed multi-fluid plasma simulation in a plasma with streaming CRs.

## What is the result?

We found two new generation mechanisms of magnetic field, which are induced by the streaming CRs. The first CRs can generate  $B \sim 10^{-20}$  G at  $z \sim 20$  by the Biermann battery.