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May spectral features of cosmic ray fluxes be explained by a conspiracy of the sources in space-time?

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In the new "precision era"for cosmic ray astrophysics, theoretical predictions cannot content themselves with average trends,
but need to correctly take into account intrinsic uncertainties. The space-time discreteness of the cosmic ray sources, joined with a
substantial ignorance of their precise epochs and locations (with the possible exception of the most recent and close ones) plays an
important role in this sense. We elaborate a statistical theory to deal with this problem, relating the composite probability P(Ψ) to obtain a flux Ψ at the
Earth to the single-source probability p(ψ) to contribute with a flux ψ. The main difficulty arises since p(ψ) is a "fat tail"distribution,
characterized by power-law or broken power-law behaviour up to very large fluxes for which central limit theorem does not hold, and leading to well-known "stable laws"as opposed to Gaussian distributions.
We find that relatively simple recipes provide a satisfactory description of the probability P(Ψ). We also find that a naive Gaussian fit to simulation results would underestimate the probability of very large fluxes, i.e. several times above the average, while overestimating the probability of relatively milder excursions. At large energies, large flux fluctuations are prevented by causal considerations, while at low energies a partial knowledge on the recent and nearby population of sources plays an important role. A few proposal have been recently discussed in the literature to account for spectral breaks recently reported in cosmic ray data in terms of local contributions. We apply our newly developed theory to assess their probabilities, finding that they are relatively small.

Summary

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