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Can ultrahigh energy protons come from steady astrophysical sources?

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Among other questions, there are two long-standing mysteries about cosmic rays at the highest energies: are they mostly composed by protons or nuclei? Are their sources steady or transient? In this work, we aim to exam one out of the four scenarios led by these questions, namely, the possibility that the highest-energy particles are protons from steady sources. We start out by discussing the bolometric luminosity and the local number density of the sources required by observed events above 60-80 EeV. The requirements are then contrasted with the luminosity functions of the known steady sources in the local universe, including radio galaxies, blazars, and clusters of galaxies. Our results show that unless the intergalactic magnetic field is extremely strong, there are insufficient powerful steady sources in the nearby universe to account for the observed highest-energy cosmic rays if they have a proton composition.

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