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Black hole jets in clusters of galaxies as sources of high-energy cosmic particles

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It has been a mystery that with ten orders of magnitude difference in energy, high-energy neutrinos, ultrahigh-energy cosmic rays, and sub-TeV gamma rays all present comparable energy injection rate, hinting an unknown common origin. Here we show that black hole jets embedded in clusters of galaxies may work as sources of all three messengers. By numerically simulating the propagation of cosmic ray particles in the magnetized intracluster medium (ICM), we show that the highest-energy cosmic rays leave the source rectilinearly, the intermediate-energy cosmic rays are confined by their massive host and interact with the ICM gas to produce secondary neutrinos and gamma rays, and the lowest-energy cosmic rays are cooled due to the expansion of the radio lobes inflated by the jets. The energy output required to explain the measurements of all three messengers is consistent with observations and theoretical predictions of black hole jets in clusters.

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