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Can massive star clusters produce PeV photons?

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The LHAASO observatory recently detected a PeV photon in the direction of the Cygnus X star-forming region. A plausible origin for this emission is the association of massive stars Cygnus OB2. This raises the question whether or not massive star clusters can accelerate particles to ultra-high energies. Clustered stars heat their surrounding medium, which inflates a cavity filled with multiple shocks, strong turbulence and amplified magnetic fields. Although these are ideal conditions for particle acceleration, it is yet unclear how the different acceleration processes can act collectively to produce ultra-high energy particles.

In this work we show that even though the maximum energy of the particles accelerated in these environments is expected to be higher than in the case of isolated massive stars or supernova remnants, it is not straightforward to account for an UHE gamma-ray emission. Amongst several possibilities of acceleration mechanisms, including embedded supernova remnants, wind termination shocks or large-scale turbulent waves, a promising scenario is that of a fast supernova shock expanding in the cold wind around compact clusters. In this case, protons could be accelerated up to 10 PeV and beyond, and subsequently interact to produce PeV photons.

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