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HESS J1745-290 spectrum explained by a transition in the diffusion regime of PeV cosmic rays in the Sgr A* accretion flow

Context The diffuse TeV gamma-ray emission detected in the inner $\sim$ 100 pc of the Galactic Center suggests the existence of a central cosmic-ray accelerator reaching $\sim$ PeV energies. It is interesting to associate this so-called 'PeVatron' with the point source HESS J1745−290, whose position is consistent with that of the central supermassive black hole, Sgr A*. However, the point source shows a spectral break at a few TeV, which is not shown by the diffuse emission, challenging this association.
Aims We seek to build an emission model for the point source consistent with both emissions being produced by the same population of relativistic protons, continuously injected with a power-law spectrum up to $\sim$ PeV energies, near Sgr A*.
Methods In our model, we assume that the point source is produced by hadronic collisions between the cosmic rays and the gas in the accretion flow of Sgr A*. The cosmic-ray density is calculated taking into consideration cosmic-ray transport due to diffusion and advection, while the properties of the gas are obtained from previous numerical simulations of the accretion flow.
Results Our model succeeds in explaining both the point source and the diffuse emission with the same cosmic rays injected in the vicinity of Sgr A*, as long as the coherence length of the magnetic turbulence in the accretion flow is $l_c \sim (1-3) \times 10^{14}\,\mathrm{cm}$. The spectral break of the point source appears naturally due to an energy-dependent transition in the way the cosmic rays diffuse within the inner ~ 0.1 pc of the accretion flow (where most of the emission is produced).
Conclusions Our model supports the idea that Sgr A* can be a PeVatron, whose accelerated cosmic rays give rise to both the point source and the diffuse emission. Future TeV telescopes, like CTAO, will be able to test this model.

Collaboration(s)

Authors: MUENA TOLEDO, Claudio; Dr RIQUELME, Mario (University of Chile); Dr REISENEGGER, Andreas (Metropolitan University of Educational Sciences); Mr SANDOVAL, Astor (University of Chile)

Presenter: MUENA TOLEDO, Claudio

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