

Astrophysical signatures from Galactic positronium, true muonium and true tauonium

Tuesday, 29 November 2016 16:50 (20 minutes)

The annihilation of electrons and positrons in the Galactic centre has been observed since the 1970s, yet the origin of the positrons is still unknown. Models of high energy astrophysical sources, such as supernovae and low mass X-ray binaries, must be able to explain the very high bulge-to-disc ratio of the annihilation emission, either via the distribution of the sources or via the propagation of the positrons through the ISM. Alternative possibilities include dark matter decay, or the supermassive black hole, both of which would have a naturally high bulge-to-disc ratio.

The chief difficulty in reconciling models with the observations is the intrinsically poor angular resolution of gamma ray observations, which cannot resolve point sources. However, 95% of the positrons annihilate via the formation of positronium, a short lived atom consisting of an electron and a positron. This gives rise to the possibility of observing recombination lines of positronium emitted before the atom annihilates. These emission lines would be in the UV and the NIR, giving an increase in angular resolution of a factor of 10^4 compared to gamma ray observations, and allowing the discrimination between point sources and truly diffuse emission.

Analogously to the formation of positronium, it is possible to form atoms of muons and anti-muons and taus and anti-taus. Since muons and taus are intrinsically unstable, the formation of such leptonium atoms will be localised to their places of origin. Thus observations of true muonium or true tauonium can provide another way to distinguish between truly diffuse sources such as dark matter decay, and point sources such as supernovae, etc.

We will review the possibility of detecting positronium recombination lines, and the observational signatures of leptonium from astrophysical sources, and discuss the possibilities of resolving the problem of the origin of the Galactic positrons.

Summary

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Session Classification: Particle astrophysics