Contribution ID: **168** Type: **Oral Contributions**

Why the GeV gamma-ray excess cannot originate from DM

Thursday, 15 September 2016 15:20 (20 minutes)

An excess of diffuse gamma-rays towards the Galactic Center (GC) is usually assumed to originate from the GC with the most exciting interpretations being the contributions from dark matter (DM) annihilation and/or unresolved sources, like millisecond pulsars.

Up to now no studies have been undertaken to see if the excess occurs in other regions of the Galactic plane, which is a challenge, since the presently used methods are not suitable for such an analysis. The first method uses the diffuse galactic model from the Fermi Science Team, but this model does not provide errors and has no high spatial and spectral resolution, since it is intended to provide a smooth, polynomial background for the search for point sources. The second, most common, analysis method uses the spatial emissivity templates predicted by Galactic models. However, these models do not describe the diffuse gamma-ray emission in the Galactic plane, so they cannot be used for analysing the Galactic plane.
Therefore, we follow a different approach: we fit energy templates of the various contributions to the diffuse gamma ray spectrum in a given direction. Since the spectral shapes of the various contributions are quite different, one can disentangle the contributions by fitting the sum of the templates to the observed spectrum in finely binned cones. Well-known contributions, as implemented in the Galactic models, are π^0 production, inverse Compton scattering (IC) and Bremsstrahlung (BR). A bad χ^2 in the template fit for a certain cone indicates the need for an additional component in that direction.

Two known components missing in Galactic models are the Fermi Bubbles and the so-called source cosmic rays (SCRs), as discussed previously (arXiv:1407.4114). SCRs are the ''fresh" component of the CRs during the time they are accelerated inside the sources.
The Fermi Bubbles and the SCRs both have a gamma-ray spectrum corresponding to π^0 production from a hard $1/E^{2.1}$ nucleon spectrum (E is the nucleon rigidity), as expected for diffuse shock wave acceleration. The gamma-ray template from this hard SCR component turns out to be needed towards the Fermi Bubbles and in all directions with the presence of the 1.809 MeV line from ^{26}Al, a tracer of CR sources, which are typically embedded inside molecular clouds (MCs).

This template greatly improved the quality of the fit, but in several regions of the Galactic plane the observed maximum of the gamma-ray spectrum (multiplied with E^2 for each bin with energy E) in the data is shifted from 0.7 to 2 GeV. This can either be interpreted as a new source producing gamma-rays predominantly around 2 GeV or a depletion of gamma-rays below 2 GeV. Since we observe this shift in MCs, as was evident from the correlation of the shift with the 1.809 MeV line from ^{26}Al again (arXiv:1509.05310), it is more likely to be a depletion, which can happen in dense MCs. The reason is rather simple:
MCs have a mass substructure of filaments and cloudlets which are embedded in high magnetic fields. If cosmic rays (CRs) enter a region of a high magnetic field, we know from CRs approaching the earth, that most of the CRs with rigidities below 20 GV do not reach the earth because of the geomagnetic cut off in the earth magnetic field. Since the magnetic moment of the cloudlets inside MCs have easily a magnetic moment similar to the earth, we expect that low energy nuclei will not enter the cloudlets, thus depleting the gamma-ray spectrum from MCs regions at low energies. This leads to a shift in the maximum of the gamma-ray spectrum from MCs towards higher energy, usually called the gamma-ray excess. In reality, it is a depletion at low energies inside MCs, as expected from the strong correlation in space between the shift in the gamma-ray spectrum and the occurrence of the ^{26}Al line. The regions with the shift were identified after including a template from gamma-ray production with a break in the proton spectrum at 13 GV, which yields a maximum in the gamma-ray spectrum at 2 GeV.

The ^{26}Al line is strong towards the GC, where the gas in the inner Galaxy is dominated by the Central Molecular Zone, towards the central Bar region and towards the tangent point of the spiral arms and a few star-forming regions like the Cygnus region. Exactly towards these region we observe the shift in the maximum of the gamma-ray spectrum. Since this morphology contradicts the morphology from DM, the DM interpretation is excluded by this observation.

Summary

A 2015 Nature article entitled: „Mysterious Galactic Signal points LHC to Dark Matter(DM)"discusses the

so-called GeV gamma-ray excess in the Galactic Center (GC), see
http://www.nature.com/news/mysterious-galactic-signal-points-lhc-to-darkmatter-1.17485. This excess has been widely discussed in the literature as a possible DM signal.
We prove that this excess in not only from the GC, but observed in all directions of star-forming molecular cloud regions. Hence, it is not connected to DM. We show that the excess is easily explained by the propagation of cosmic rays in the dense environment of molecular clouds, thus making an essential step towards solving this outstanding problem.

Primary author: DE BOER, Wim (KIT - Karlsruhe Institute of Technology (DE))

Presenter: DE BOER, Wim (KIT - Karlsruhe Institute of Technology (DE))

Session Classification: Dark matter (indirect detection)

Track Classification: Dark matter (indirect detection)