The dark matter disk: a viable explanation of the cosmic positron excess

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1. What is the cosmic positron excess and why is it interesting?

In 2009 the **PAMELA** experiment[2] discovered an unexpected excess of cosmic positrons (w.r.t. secondary positrons) at energies above ~ 10 GeV, which was later confirmed by **AMS-02**[3].

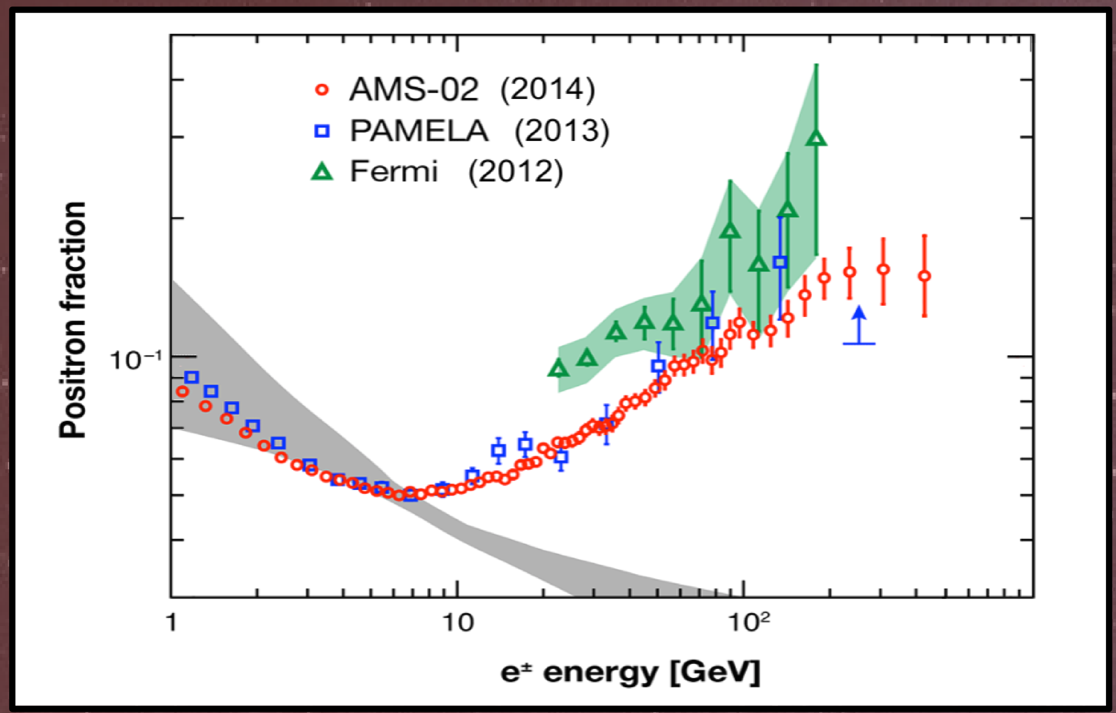

Fig.1 Positron fraction measured in different experiments

This phenomenon has gained a lot of interest since known sources and mechanisms couldn't explain it, so one **needed to introduce new local sources** of high-energy positrons.

2. Can dark matter annihilations or decays produce this excess?

It is not that hard to build a dark matter model that produces high-energy positrons and fits the AMS-02 data very nicely. However, all these models usually also produce a lot of gamma rays, which would contribute to the isotropic gamma-ray background (IGRB) and hence are strictly **constrained** by the **Fermi-LAT IGRB measurements**[4].

As we have shown in our paper[1], even when one starts with an *ad hoc* injection spectrum of positrons, which fits the AMS-02 data very well (Fig. 2) and **only counts** gamma rays coming directly **from positrons**, such as final state radiation, inverse Compton photons and Bremsstrahlung, the resulting diffuse gamma-radiation **hardly stays** within the existing most conservative Fermi-LAT limit. Taking into account the fact that the measured IGRB has a **significant contribution** from unresolved **blazars**[5], one sees a **clear contradiction**, especially at high energies. Thus, the excess of positrons **cannot come** from annihilating or decaying dark matter, if it is distributed isotropically in the halo.

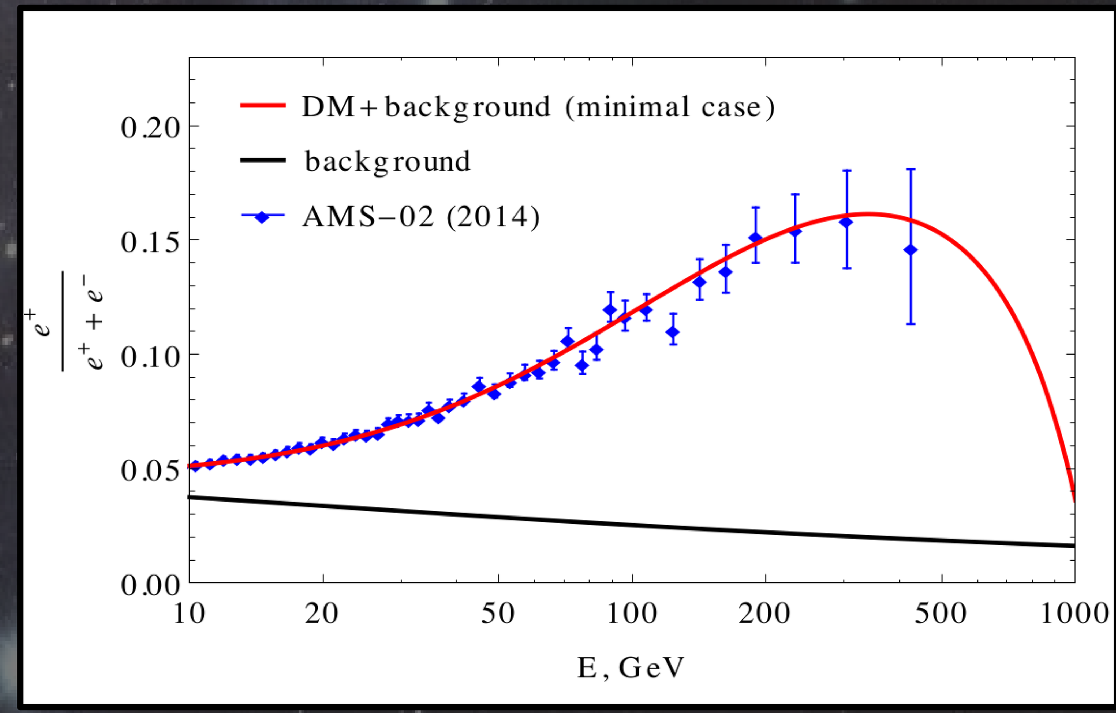

Fig.2 Minimal model fitted to the AMS-02 data

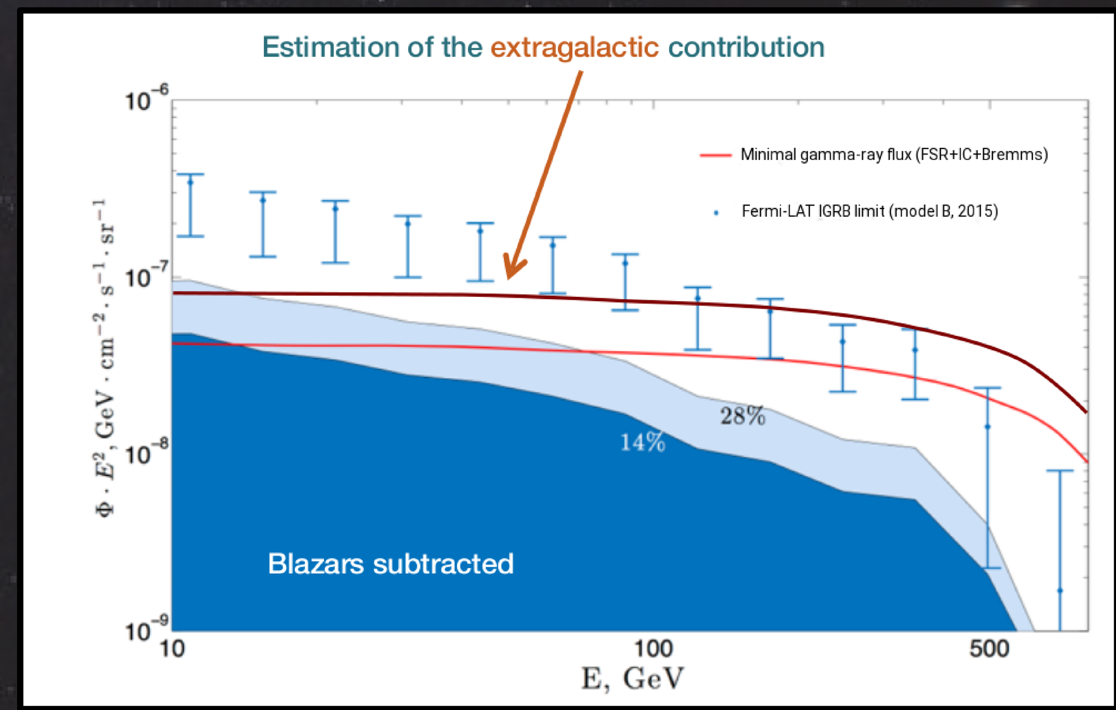

Fig.3 Diffuse gamma rays from minimal model compared to the IGRB data

3. What is a dark matter disk? Why do we consider it?

The idea that **self-interacting** dark matter can **dissipate** energy and form a disk-like structure, as baryons do, was proposed before in particular to explain the periodicity of comet impacts[6] and planar the distribution of Andromeda satellites[7]. If annihilating or decaying dark matter is mostly **concentrated within this disk** then it can still fit the positron data very well, while the contribution to the diffuse gamma-ray background would be **significantly suppressed**.

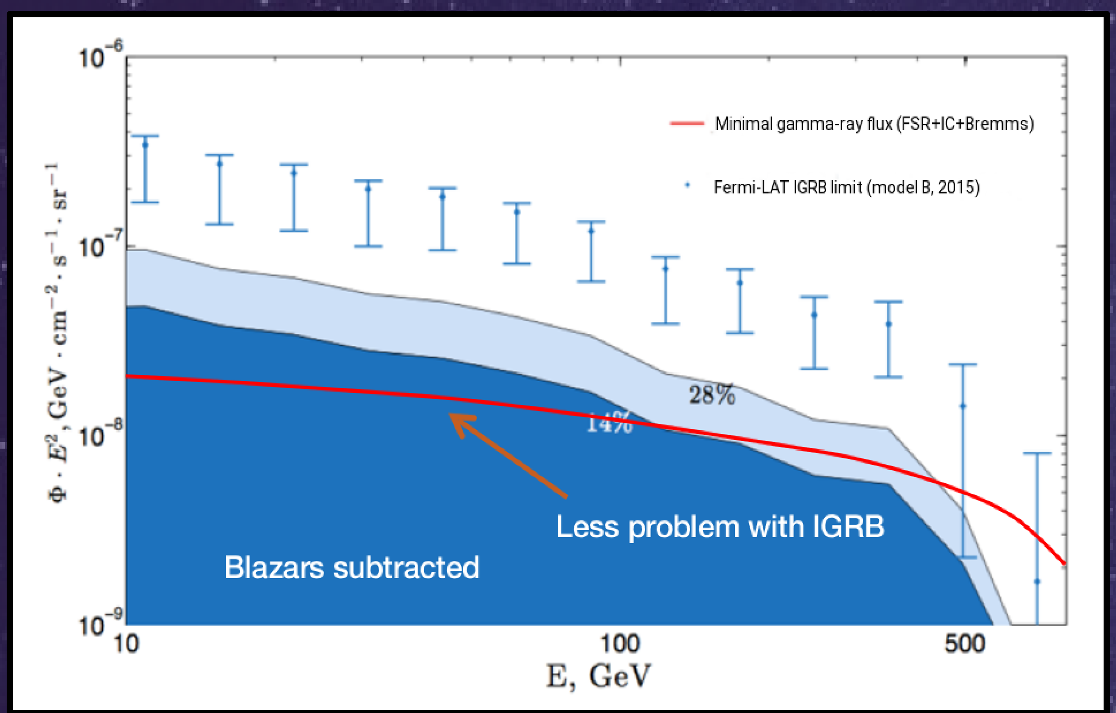

Fig.4 Diffuse gamma rays from the dark disk (minimal) compared to the IGRB data

Our calculations show (Fig. 4) that in the case of a ~ 1 kpc thick disk the tension described above (Section 2, see Fig. 3) is substantially relieved.

Conclusions

The dark matter explanation of the cosmic positron excess is severely constrained by IGRB measurements. The dark disk model, in which annihilating or decaying dark matter is concentrated within a thick disk can possibly evade this constraint.

References

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