Cosmic Ray propagation

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Latest Results in Dark Matter Searches

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Cosmic Rays





Cosmic Rays





Discoveries in Cosmic Rays Positron (1932) Muon (1936) Pion (1947) Kaon (1947) **Pierre Auger Victor Hess** Lambda (1951) Neutralino (201x)?



Charles Wilson Carl Anderson



Vitaly Ginzburg

Supernova remnants

 $Q_0 E^{-\gamma} e^{-E/E_c}$





• Supernova remnants

• Pulsars (electrons only)



 $Q_0 E^{-\gamma} e^{-E/E_c}$



• Supernova remnants

Pulsars

• Cosmic rays $\sigma(p_{CR} + H_{ISM} \Rightarrow \text{C.R.})$



Supernova remnants

Pulsars

• Cosmic rays

• Dark Matter (annihilation or decay)?





















Diffusion equation

$$\partial_t \Psi + \vec{\nabla} \cdot \left(\vec{V_c} \Psi - K \vec{\nabla} \Psi \right) + \partial_E \left(b_{loss} \Psi - D_{EE} \partial_E \Psi \right) = Q - D_{EE} \partial_E \Psi$$

Diffusion coefficients are not fixed on first principle basis

Many free parameters.

In the simplest models at least 5 coefficients

 $K = K_0 R^{\delta} \delta$ diffusion cofficient

L halo size

Vc convective wind

Va = Alfvén speed



Solving the equation

Different methods exist

Full numerical resolution GALPROP DRAGON

Semi-analytical group from Annecy, Grenoble and Turin

Both have pros and cons but semi-analytical is faster and gives a better understanding

Constraining the parameters





Putze et al. A&A 516 (2010) A66

Radioactive species



Putze, Derome & Maurin ArXiv:1001.0551

Cosmic Rays





Why should someone care ?

Fluxes at the Earth (of course!)

Secondary tracers : neutrinos, γ -rays (π° , inverse-Compton, synchrotron, Bremsstrahlung)

Foregrounds and backgrounds to many experiments

Subtraction methods cause artifacts (see Mertsch & Sarkar 2010)

Positrons & Électrons



Positrons and Electrons

Need to understand better the losses

Modeling of the InterStellar Radiation Field

Modeling of the Galactic Magnetic Field

Sources

Local Sources



Delahaye, Kotera & Silk (2014), see also Di Mauro et al. (2014)

positron fraction : e+ / e+ + e-

Proton and Helium





Is our model safe ?



Bernard, Delahaye, Salati & Taillet (2012)

Catalogues



Bernard, Delahaye, Salati & Taillet (2012)

Taking the catalogue into account

 10^{6}



Many other possible explanations

Distorsion at injection (Yuan et al 2011)

Diffusion effect (Malkov et al. 2012)

Second class of sources (Stanev et al. 1993)

Local diffusion coefficient (Hörandel et al 2007)

Numerical models are in trouble

Is there really a problem ?





Positrons and Dark Matter



Bergström et alii (2013)



Anti-protons



Anti-Helium





Cirelli et alii 1401.4017

Carlson et alii 1401.2461



Conclusion

A lot of work remains to be done because in the era of precision astrophysics and cosmology we cannot be satisfied such such crude models

Eventhough, cosmic-rays are quite constraining already for dark matter and it is competitive with the LHC, direct searches and cosmology

We need data \rightarrow AMS-02, GAPS