Highlights of Astronomy, Volume 15
XXVIIth IAU General Assembly, August 2009
Ian F. Corbett, ed.

doi:10.1017/S1743921310009087

On the correlation of the highest energy cosmic rays with AGNs

Vitor de Souza[1] **and Peter L. s Biermman**[2]

[1]Instituto de Física de São Carlos, Universidade de São Paulo, Brazil
email: vitor@ifsc.usp.br

[2]MPI for Radioastronomy, D-53121 Bonn, Germany
email: plbiermann@mpifr-bonn.mpg.de, Also at: Univ. of Bonn, Univ. of Alabama, Tuscaloosa, AL, Univ. of Alabama at Huntsville, and at KIT Karlsruhe

Abstract. In this paper we briefly discuss the present status of the cosmic ray astrophysics under the light of the new data from the Pierre Auger Observatory. The measured energy spectrum is used to test the scenario of production in nearby radio galaxies. Within this framework the AGN correlation would require that most of the cosmic rays are heavy nuclei and are widely scattered by intergalactic magnetic fields.

Keywords. Ultra-high energetic particles, AGN correlation, energy spectrum.

1. Introduction

The production mechanism of particles with energy above 10^{20} eV has been a puzzle since 1963 when the first measurement was done. Several models have been proposed but the lack of experimental constraints allowed a wide range of possibilities. This panorama has recently started to change specially after the publication of a correlation of the arrival direction of these particles with the position of AGNs done by the Pierre Auger Collaboration [Auger Collaboration (2007)]. Since then, new scenarios have been considered. Among all candidates AGN jets [Benford & Protheroe (2008)] and powerful radio galaxies [Rachen & Biermann (1993)] are the most favored by present data [Allard & Protheroe (2009)].

Generally speaking, models based on sources cosmologically distributed tends to: a) generate an abundance of light particles, b) requires low intergalactic magnetic fields to describe the AGN correlation and c) describes the flux suppression above 4×10^{19} eV as the interaction of the particles with the CMB [Berezinsky *et al.* (2006)]. On the other hand, models based on local powerful sources tends to: a) generate a high flux of heavy particles, b) requires high intergalactic magnetic fields to describe the AGN correlation and c) describes the flux suppression above 4×10^{19} eV as the limit of the sources.

In this short article we discuss the possibility of accelerating cosmic rays in nearby radio galaxies and compare the resulting energy spectrum with the one measured by the Pierre Auger Observatory. Figure 1 shows the good agreement between this model and the data. Since none of these sources in our cosmic neighborhood accelerates protons to such high energy, according to arguments derived from the jet energetics [R. V. E. Lovelace (1976)], heavy nuclei seem to be required. Such a heavy composition would also be favored by the recent data of the Auger Observatory [Auger Collaboration (2009)].

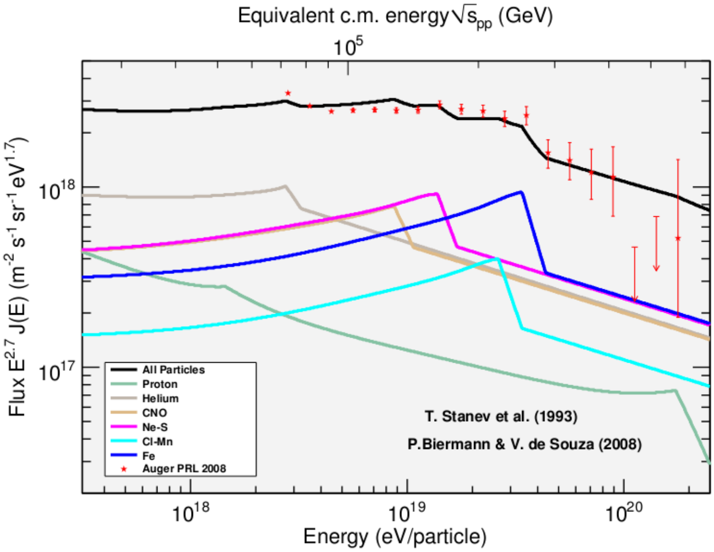

Figure 1. Energy spectrum of cosmic rays produced in radio galaxies as devised originally by Stanev *et al.* (1993) and energy shifted according to P.L.Biermann *et al.* (2009) compared to the spectrum measured by the Pierre Auger Observatory [Auger Collaboration (2008)].

2. Model Discussion

This model is based on the original argument presented by Biermann & Strittmatter (1987). In this model, a galaxy merger is considered though all its stage. Considering the standard evolution of the merging, going from the initial starburst to the spinflip of the more massive black hole, one is able to predict the formation of jets. The starburst provides through its wind-SNe the seed particles for the one-step acceleration in the jet. Applying the results of Y.-A. Gallant & A. Achterberg (1999) we can push the energy particles of the previous model up by a factor of Γ^2, leading to ultra high energy cosmic rays (UHECR).

Radio interferometry of this source have shown that in the spine of this jets Lorentz factor can reach 50 [P.L.Biermann *et al.* (2009)]. Therefore, the spectrum with all its heavy abundances is shifted straight to ultra high energy, and the fit actually is consistent with the Auger data. In this case, the most prominent source of UHECR would be Cen A.

Acknowledgements

V. de Souza is supported by FAPESP (2008/04259-0). Support for work with P. Biermann has come from the AUGER membership and theory grant 05 CU 5PD 1/2 via DESY/BMBF and VIHKOS.

References

Stanev, T., Biermann, P. L. & Gaisser, T. K. 1993, *Astron. and Astroph.* 274, 902.
Allard, D. & Protheroe, R. - *arXiv:0902.4538*.
Benford, G. & Protheroe, R. 2008, *MNRAS* 383, 663.
Rachen, J. P. & Biermann, P. L. 1993, *Astron. Astrophys.* 272,161.
The Pierre Auger Collaboration 2007 *Science* 318,938-943.
Berezinsky, V. *et al.* 2006 *Phys. Rev. D* 74,043005.
R. V. E. Lovelace 1976 *Nature* 262,649.
Biermann, P. L. & Strittmatter, P. A. 1987 *ApJ* 322,643.

The Pierre Auger Collaboration 2009, M. Unger, SOCoR workshop, Trondheim; V. de Souza,"Window on the Universe",Blois, France; J. Bellido, 31st ICRC, Lodz, Poland.

Y.-A. Gallant, & A. Achterberg *Month. Not. Roy. Astr. Soc.* 305,L6 - L10

P. L. Biermann *et al.* - *arXiv:0904.1507.*

The Pierre Auger Collaboration 2008 *Phys. Rev. Letters* 101,061101.

https://doi.org/10.1017/S1743921310009087 Published online by Cambridge University Press