EXAMPLE OF A PAPER PRESENTED AT THE VULCANO WORKSHOP 2004: FRONTIER OBJECTS IN ASTROPHYSICS AND PARTICLE PHYSICS

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Abstract

In this paper I would like to discuss several hot points of today astroparticle physics.

1 Introduction

In the last few decades, cosmic-ray physics and high energy astrophysics strongly developed thanks to ground- and space-based experiments. Higher and higher capabilities in reproducing extreme conditions in which the nature demonstrates, and better and better sensitivities of the detectors used have been the key of such a development.

2 Cosmology

Modern physical cosmology has now converged on the Big Bang framework. Such a framework is supported by four principal pillars:

- Hubble expansion
- microwave background
- light element abundances
- inflation

2.1 Hubble Expansion

The absolute magnitude M of the galaxies can be determined through the measurement of the apparent magnitude m and redshift z.

2.1.1 Title of the Subsubsection

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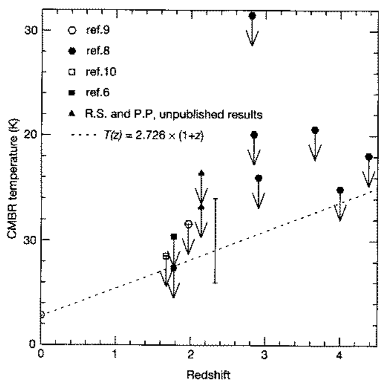

Figure 1: CMBR temperature versus redshift (Srianand, Petitjean & Ledoux, 2000). **We want the Figure 1 just here, then it is necessary to use the command [h!].**

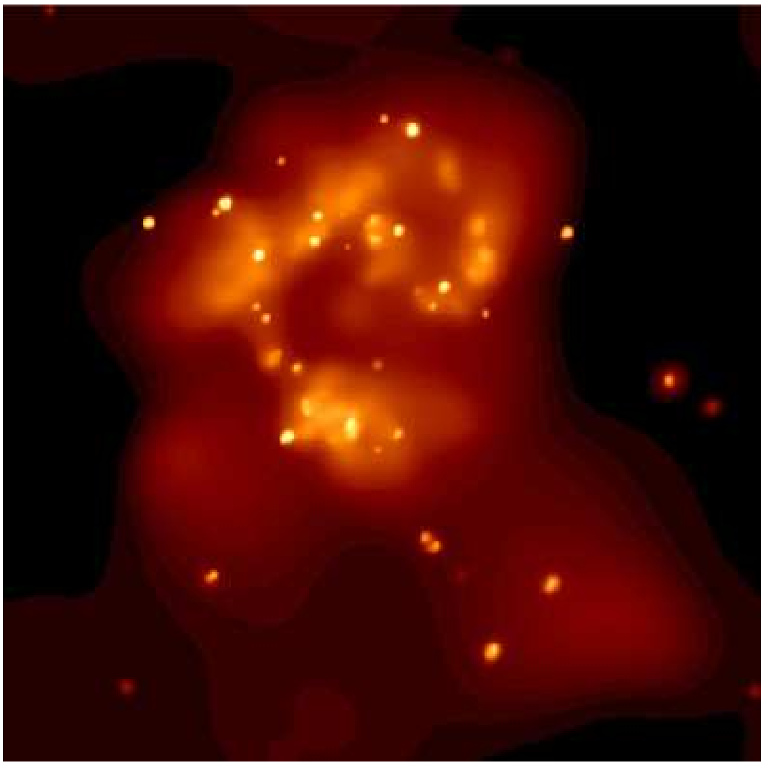

Figure 2: Image of the Antennae colliding galaxies obtained with the Chandra observatory. It shows superbubbles produced by the combined effect of thousands of supernovae, as well as dozens of bright point-like sources produced by neutron stars and black holes (NASA/SAO/Fabbiano, Zezas & Murray, 2001). **We want the Figure 2 at the top of page, then it is necessary to use the command [t!].**

3 Active Galactic Nuclei and Galactic Collapsed Objects: Unified Schemes

The main idea in order to explain the emission from extragalactic X-ray emitters, now very popular, was suggested many years ago (Giovannelli & Polcaro, 1986): the *engine* producing high energy radiation is of the same kind for all extragalactic emitters. Mass and mass accretion rates are the unique parameters differentiating extragalactic emitters, containing central black holes, by the galactic black holes.

More detailed unified schemes have been produced. For instance, in

Vagnetti, Cavaliere & Giallongo (1991) and Vagnetti & Spera (1994) and in the references therein, the evolutionary unified scheme is based on the changing balance among three optical luminosities, namely:

- nuclear isotropic component;
- relativistic beam component;
- host galaxy component.

The intrinsic jet luminosity is assumed to have the same cosmic evolution as the nuclear isotropic component. The bulk Lorentz factor of the beam is able to account for the slower evolution of flat-spectrum QSOs. The comparison of the total nuclear luminosity ($L_{NUC} = L_{IS} + L_{BEAM}$) with the non-evolutionary galactic luminosity, (L_{HG}), predicts the appearance of a source as a radio galaxy if $L_{HG} > L_{NUC}$.

Table 1 shows 28 GRBs detected by different satellites, for which the redshifts of the *host galaxies* have been determined (Djorgovski et al., 2001; Greiner, 2002).

4 X-Ray Binaries

X-ray binary systems are a cauldron of physical processes and their multi-frequency studies improved a lot the knowledge of the accreting processes onto collapsed objects.

5 Radio Pulsars, Millisecond Pulsars

The observable quantities are the rotational period P and the spin-down rate $\dot{P}$. Then substituting these quantities to Ω and $\dot{\Omega}$, it is possible to express the pulsar magnetic field in terms of the observable quantities, by using typical values for the moment of inertia and the radius of the neutron star (Ziółkowski, 1997):

$$B = 3.2 \times 10^{19} (P\dot{P})^{1/2} G\,. \qquad (8.3)$$

The rate of energy loss is (Thompson, 2000):

$$\dot{E} \simeq 4 \times 10^{46} \dot{P} P^{-3}\, erg\, s^{-1}\,. \qquad (8.4)$$

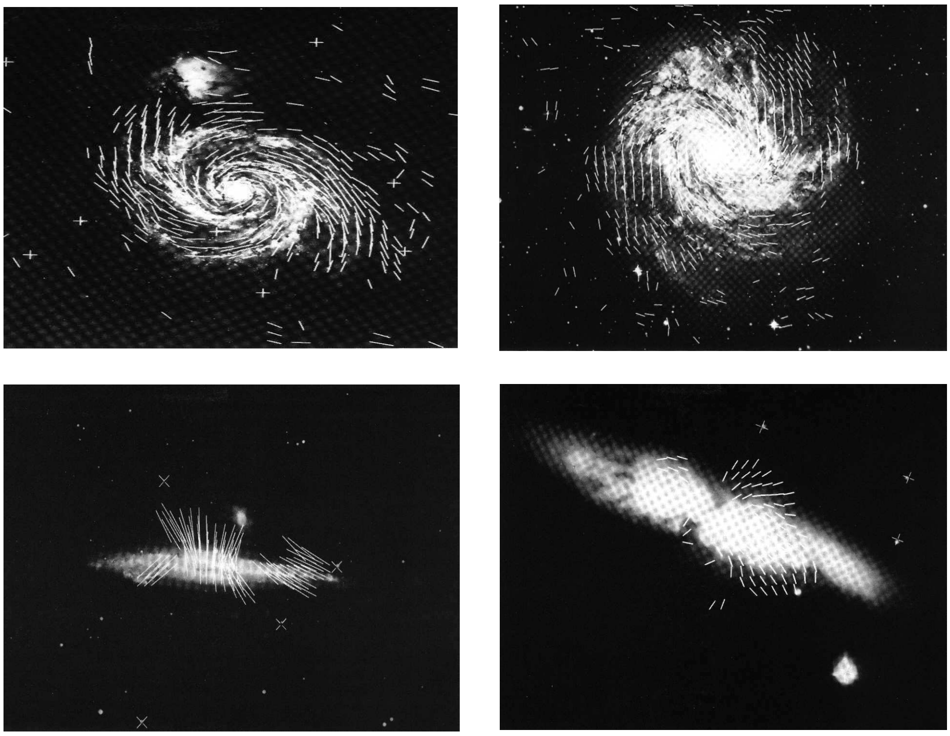

Figure 3: The magnetic field structures of different galaxies. Clockwise from the left upper panel: orientation of the large-scale magnetic fields in M51, orientation of the large-scale magnetic fields in M83 (Neininger et al., 1991), magnetic fields in NGC 4631 from 2.8 cm observations (Wielebinski & Krause, 1993), and magnetic fields in M82 from VLA observations (Reuter et al., 1993).
The use of the commands for this composed figures is rather simple. It is necessary to vary "voffset" and "hoffset" in order to move each figure in vertical and in horizontal, respectively. It is necessary to vary "hscale" and "vscale" in order to resize each figure in horizontal and in vertical, respectively. With the command "angle" it is possible to rotate a figure.

The line open field line voltage is (Thompson, 2000):

$$V \simeq 4 \times 10^{20} \dot{P}^{1/2} P^{-3/2} \, V \simeq \dot{E}^{1/2} \,. \tag{8.5}$$

Although no single model for high-energy emission from pulsars has emerged, the observations with the present generation of high-energy telescopes have channelled all models in certain directions:

- the particle acceleration by the strong electric fields takes place some-

Table 1: Gamma-ray bursts, detected by different satellites and the redshifts of the host galaxies (Djorgovski et al., 2001; Greiner, 2002)

GRB Name	Host-Galaxy Redshift	Localization Source
970228	0.625 ± 0.002	BeppoSAX
970508	0.835	BeppoSAX
970828	0.9579	RXTE/ASM
971214	3.418	BeppoSAX
980326	1 ?	BeppoSAX
980329	¡ 3.9	BeppoSAX
980425	0.0085	BeppoSAX
980613	1.0964 ± 0.0003	BeppoSAX
980703	0.9660 ± 0.0002	RXTE/ASM
990123	1.6004 ± 0.0005	BeppoSAX
990506	1.3	BATSE/PCA
990510	1.619 ± 0.002	BeppoSAX
990705	0.86	BeppoSAX
990712	0.430 ± 0.005	BeppoSAX
991208	0.7055 ± 0.0005	IPN
991216	1.020	RXTE/PCA
000131	4.50	Uly/KO/NE (IPN)
000214	0.37-0.47	BeppoSAX
000301C	2.0335 ± 0.0003	RXTE/ASM+IPN
000418	1.1185 ± 0.0007	IPN
000911	1.0585	IPN
000926	2.0369	Uly/KO/NE (IPN)
001109	0.37	BeppoSAX
010222	1.477	BeppoSAX
010921	0.45	HETE/Uly/BeppoSAX
011121	0.36	BeppoSAX
011211	2.14	BeppoSAX
020405	0.69	Uly/MO/BeppoSAX

where above the magnetic poles;

- the principal high-energy emission processes are synchrotron radiation,

Table 2: Black holes in the Milky Way Galaxy (Blandford & Gehrels, 1999; Filippenko et al., 1999; Casares, 2001)

Source Name	Identification	Companion	f(M)	M_{Opt} ($M_\odot$)	M_{BH} ($M_\odot$)
Cygnus X-1	HD226868	O9.7 Iab	0.24	24-42	11-21
GS2023+338	V404 Cyg	K0 IV	6.26	~ 0.6	10-15
GS2000+25	QZ Vul	K3-K5 V	4.97	~ 0.7	6-14
H1705-250	V2107 Oph	K3	4.86	0.3-0.6	6.4-6.9
GROJ1655-40	N Sco 1994	F6 IV	3.24	2.34	7.02
A0620-00	V616 Mon	K3-K5 V	3.18	0.2-0.7	5-10
GS1124-68	GU Mus	K3-K4 V	3.10	0.5-0.8	4.2-6.5
GROJ0422+32	V518 Per	M2 V$\pm$2	1.21	~ 0.3	6-14
4U1543-47		A2 V	0.22	~ 2.5	2.7-7.5
GRS1009-45	N Vel 1993	K8 V$\pm$2	3.17	~ 0.6	4.4

curvature radiation, and inverse Compton scattering, with thermal-emission secondary contributor;

- the high-energy pulsed emission is probably associated with a single magnetic pole of the neutron star.

Thompson (2000) pointed out several open questions about spin-down pulsars:

- Where in the magnetosphere are the particles accelerated?
- What is the shape of the beam?
- Are there many more radio-quiet pulsars to be found in X-rays and γ-rays?
- How do these recent discoveries affect our thinking about supernovae and neutron star formation?

These open questions can be solved by improving the studies of the X-ray archives of the ROSAT, ASCA, BeppoSAX, and RXTE, while AXAF-Chandra, and XMM-Newton will give significant improvements in sensitivity and resolution. In the γ-ray range, the study of the CGRO archives and the new data from the INTEGRAL mission will help in filling some gaps in such a low-energy γ-ray band. The next major step in high-energy γ-rays will come with the GLAST experiment (e.g. Kamae, et al., 2000).

6 Conclusions

In this paper I have discussed several of the most important problems of astroparticle physics today and the hot questions still open have been remarked.

7 Acknowledgements

This work was partially supported by the European Community. Many thanks to Drs Black and White for useful discussions.

References

[1] **We strongly recommend to insert in the text the references with the name of the author and the date, like (Beall, 2002) or following the results obtained by Baade & Zwicky (1934) or, in the case of three authors we suggest to write the three names (Beall, Guillory & Rose, 1999). For more than three authors please use: following the paper by Atkins et al. (2000) we can deduce..... or: the result of this measurement has been used for obtaining a new model of the system (Bednarek et al., 1990).**

We strongly recommend to write the references in this section in alphabetical order. It is much easier to find them in any moment!

[2] Atkins, R., Benbow, W., Berley, D., Chen, M.L., Coyne, D.G., Dingus, B.L., Dorfan, D.E., Ellsworth, R.W., Evans, D., Falcone, A., Fleysher, L., Fleysher, R., Gisler, G., Goodman, J.A., Haines, T.J., Hoffman, C.M., Hugenberger, S., Kelly, L.A., Leonor, I., McConnell, M., McCullough, J.F., McEnery, J.E., Miller, R.S., Mincer, A.I., Morales, M.F., Nemethy, P., Ryan, J.M., Shen, B., Shoup, A., Sinnis, C., Smith, A.J., Sullivan, G.W., Tumer, T., Wang, K., Wascko, M.O., Westerhoff, S.,

Williams, D.A., Yang, T., Yodh, G.B.: 2000, *Astrophys. J. Letters* **533**, L119.

[3] Baade, W. and Zwicky, F.: 1934, *Phys. Rev.* **45**, 138.

[4] Backer, D., Kulkarni, S., Heiles, C., Davis, M., Goss, M.: 1982, *IAU Circ.* **No. 3743**.

[5] Bailes, M., Lorimer, D.: 1995, in *Millisecond Pulsars. A Decade of Surprise*, A.S. Fruchter, M. Tavani & D.C. Backer (eds.), ASP Conference Series **72**, 17.

[6] Baring, M.G., Harding, A.K.: 1997, in *Proceedings of the Fourth Compton Symposium*, C.D. Dermer, M.S. Strickman & J.D. Kurfess (eds.), AIP Conf. Proc. **410**, 638.

[7] Bartolini, C., Beskin, G.M., Guarnieri, A., Masetti, N., Piccioni, A.: 1998, in *Gamma-Ray Bursts*, C.A. Meegan, R.D. Preece & T.M. Koshut (eds.), AIP Conference Proceedings **428**, 540.

[8] Beall, J.H.: 2002, in *Multifrequency Behaviour of High Energy Cosmic Sources*, F. Giovannelli & L. Sabau-Graziati (eds.), *Mem. S.A.It.* **73**, 379.

[9] Beall, J.H., Guillory, J., Rose, D.V.: 1999, in *Multifrequency Behaviour of High Energy Cosmic Sources*, F. Giovannelli & L. Sabau-Graziati (eds.), *Mem. S.A.It.* **70**, 1235.

[10] Becker, W.: 2000, *Adv. Space Res.* **25**, 647.

[11] Becker, W., Trúmper, J.: 1997, *J. Astron. Astrophys.* **326**, 682.

[12] Becker, W., Trúmper, J.: 1997, *J. Astron. Astrophys.* **326**, 682.

[13] Becker, W., Trúmper, J.: 1998, in *The Many Faces of Neutron Stars*, R. Buccheri, J. van Paradijs & M. A. Alpar (eds.), Kluwer Academic Publ., p. 525.

[14] Bednarek, W., Giovannelli, F., Karakula, S., Tkaczyk, W.: 1990, *Astron. Astrophys.* **236**, 268.

[15] Bednarek, W., Giovannelli, F.: 1999, in *Multifrequency Behaviour of High Energy Cosmic Sources*, F. Giovannelli & L. Sabau-Graziati (eds.), *Mem. S.A.It.* **70**, 1071.

[16] de Bernardis, P., Ade, P.A.R., Bock, J.J., Bond, J.R., Borrill, J., Boscaleri, A., Coble, K., Crill, B.P., De Gasperis, G., Farese, P.C., Ferreira, P.G., Ganga, K., Giacometti, M., Hivon, E., Hristov, V.V., Iacoangeli, A., Jaffe, A.H., Lange, A.E., Martinis, L., Masi, S., Mason, P.V., Mauskopf, P.D., Melchiorri, A., Miglio, L., Montroy, T., Netterfield, C.B., Pascale, E., Piacentini, F., Pogosyan, D., Prunet, S., Rao, S., Romeo, G., Ruhl, J.E., Scaramuzzi, F., Sforna, D., Vittorio, N. : 2000, *Nature* **404**, 955.

[17] Bhattacharya, D.: 1995, *J. Astron. Astrophys.* **16**, 217.

[18] Bildsten, L., Strohmayer, T.: 1999, in *Physics Today* **52, No. 2**, 40.

[19] Bisnovatyi-Kogan, G.: 2002, in *Multifrequency Behaviour of High Energy Cosmic Sources*, F. Giovannelli & L. Sabau-Graziati (eds.), Mem. S.A.It. **73**, 357.

[20] Fabbiano, G., Zezas, A., Murray, S.S.: 2001, *Astrophys. J.* **554**, 1035.

[21] Feroci, M.: 2001, in *Frontier Objects in Astrophysics and Particle Physics*, F. Giovannelli & G. Mannocchi (eds.), Italian Physical Society, Editrice Compositori, Bologna, Italy, **73**, 287.

DISCUSSION

MARIO MACRI: Can you comment on the contribution of Antimatter search in space experiments to the understanding of cosmological evolution?

FRANCO GIOVANNELLI: The detection of exotic cosmic rays due to pair annihilation of dark matter particles in the Milky Way halo is a viable techniques to search for supersymmetric dark matter candidates. The study of the spectrum of gamma-rays, antiprotons and positrons offers good possibilities to perform this search in a significant portion of the Minimal Supersymmetric Standard Model parameter space. ....

JAMES WHITE's Comment: I would like to remind that..........