Personal reminiscences of Riccardo Giacconi

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The Effectiveness of Instabilities for the Confinement of High Energy Cosmic Rays in the Galactic Disk

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Recently it has been proposed that plasma instabilities inhibit the escape of cosmic rays from the galactic disk, and thus can explain their long term confinement. However, when the damping of these instabilities by ambipolar collisions is included, it is found that unless the neutral hydrogen density is very low, only cosmic rays with rigidities well below 100 BV are prevented from freely streaming out of the galactic disk.

It has recently been proposed that plasma instabilities may prevent cosmic rays from streaming through the interstellar medium at a velocity much larger than the Alfvén velocity (Kulsrud and Pearce 1969, Wentzel 1969). The basic idea proposed was that in the event that the streaming velocity exceeded the Alfvén speed, then hydromagnetic waves would become unstable by a resonant two-stream instability and would grow until resonance interaction of cosmic rays reduced the drift velocity to the Alfvén speed. If this mechanism were the only one operative, it would provide an attractive explanation for the 'observed' facts that cosmic rays in the galactic disk are highly isotropic and that their lifetimes are energy independent. That is, assume the cosmic rays are produced in the disk and drift out of the galaxy along lines of force. Then cosmic rays of all energies are allowed to drift out at a maximum speed equal to the Alfvén speed.

Unfortunately, the hydromagnetic waves are also subject to strong damping processes, which inhibit the growth rate of these instabilities and thus allow the cosmic rays to stream at velocities exceeding the Alfvén velocity by considerable amounts. This has the consequence that: the more cosmic rays there are which interact with a given wave, the stronger the instability and the smaller the drift velocity to which they are limited. This process was recognized in the original papers. However, it has a consequence that was not brought out in them, namely: because each energy range of cosmic rays resonates predominantly with a given wavelength range of waves, the very rare high energy cosmic rays are unable to produce a strong instability and thus can stream at a large velocity. This is in agreement with results obtained by Wentzel (1971). Thus, the above model of disk confinement would predict large anisotropies at high energies and a strong energy dependence of cosmic ray lifetimes, contrary to what is observed.

It is the purpose of this letter to give a quantitative estimate of this process and to show that astrophysical conditions are probably such that cosmic rays above 100 BV are weakly trapped. This is important because the original idea of trapping by cosmic rays has gained acceptance (Parker 1969, Ramaty *et al.* 1970).

We first give the growth rate of the hydromagnetic waves generated by cosmic rays streaming with a velocity v_R relative to the background plasma, greater than the Alfvén velocity v_A. Second, we compute the damping Γ^* of these waves produced by collisions between the charged and the neutral particles. Finally, we equate these rates (under the assumption of no other growth or damping mechanism), and draw some conclusions about v_R.

Consider a uniform magnetic field B_0 in the z direction, a uniform density n^* of protons at rest, and a uniform cosmic-ray beam streaming through the field, so that in a frame moving with velocity v_R the cosmic rays are isotropic. Then it can be shown (Wentzel 1969, Kulsrud and Pearce 1969) that hydromagnetic waves, with wave number component k_z along z and propagating parallel to

First meeting in the corridors of Harvard College Observatory, 1970, discussion of my paper

Past Commission 48 High-Energy Astrophysics for 1982-1985

Previous names:
1970: Astrophysique de Grande Energie/ High Energy Astrophysics
1985: Astrophysique des Hautes Energies/High-Energy Astrophysics

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Riccardo Giacconi

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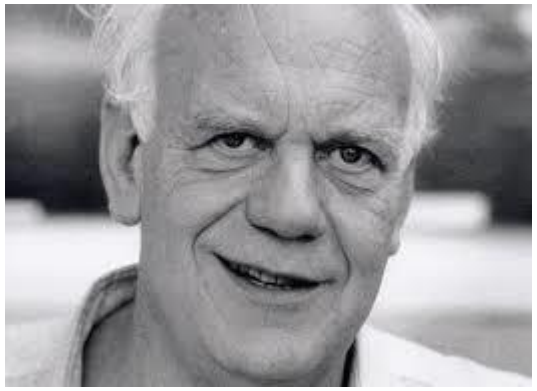
STScI



Europe

I could apreciate Riccardo's views on end to end system for a large facility, as member of STScI Visiting committee

Search Committee for ESO Director General

- Search committee chaired by Emilio Picasso, from CERN, with Immo Appenzeller, Per Olof Linblad, Ed van den Heuvel and I, from October 1991 to March 1992.
- Riccardo Giacconi was approached and asked if he would be inclined to consider an offer to become ESO DG, and replied:

I would be inclined to give the most serious consideration to an offer for the position.

- In our final report, we ranked him first, as one of the most eminent astrophysicists of our time, with unparalleled record in initiating and leading large scientific projects, and stated our conviction of his potential to make a success of the VLT.

RG at ESO, 1993-1999
CC in ESO Council, 1993-1994

December 1993: we launched an audit to assess the baseline for the VLT programme and the level of contributions necessary to carry it out

Council WG: C. Cesarsky, P. Creola, H. Grage, A. Hansen, F. Pacini

Audit found plans and costing sound.

Decision to delay VLTI.

Problems with ESO ownership of Paranal.

I was elected Council Vice-president and was part of a delegation to Chile, in May 1994, led by RG, to meet President Eduardo Frei Ruiz-Tagle in the Palacio de la Moneda.

Ultimately, a new Acuerdo was ratified in December 1996.

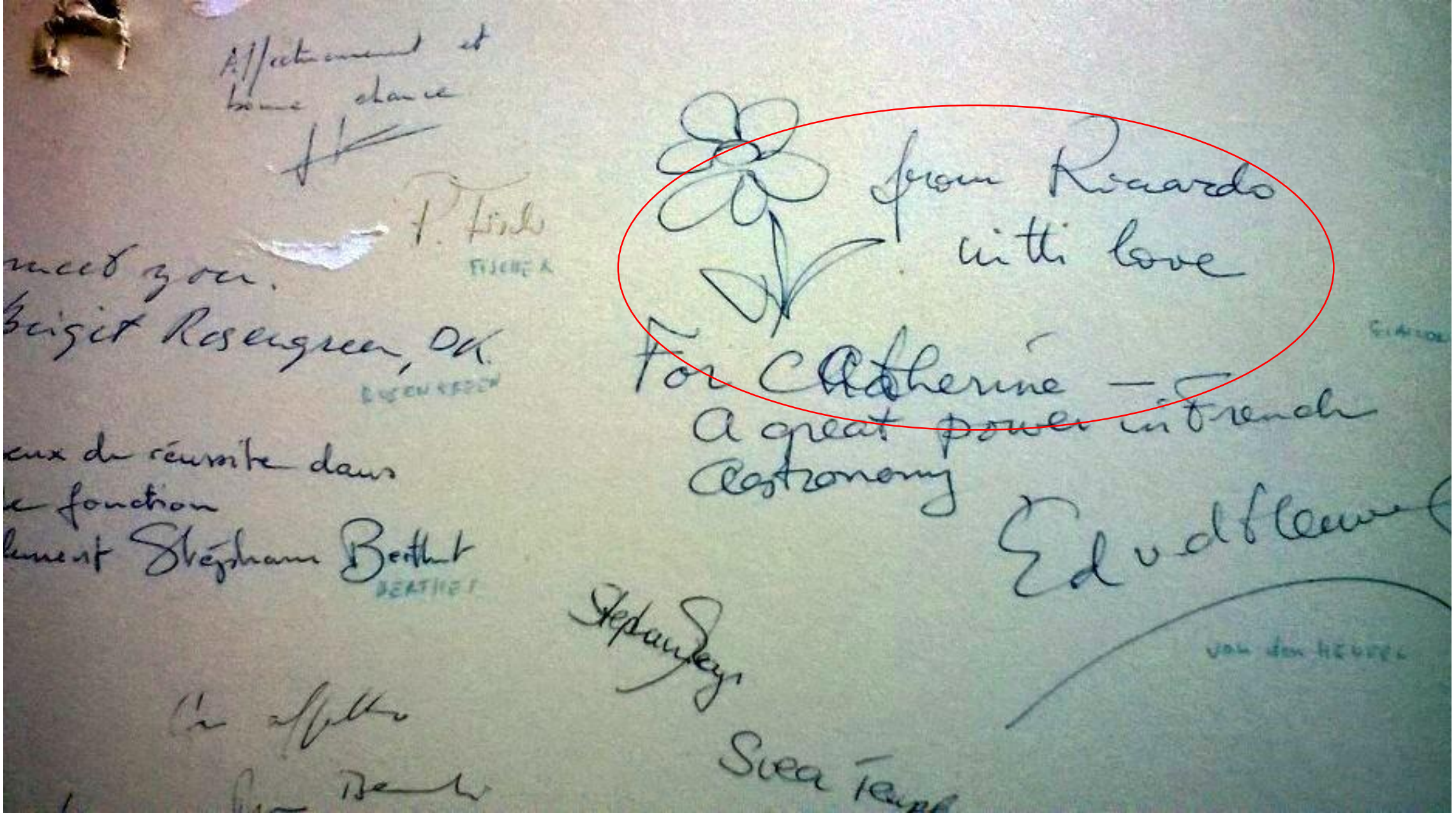
Storm in Chile

Evelyn Matthei

Arturo Alessandri

Two chilean Senators, the adversary and the supporter

ESO Guest House in Santiago



I left ESO Council end of 1994: DG and Council members farewell messages on the back of an astronomical picture

Paranal foundation ceremony, December 4 1996

RG and CC:
Visiting committees and succession at ESO

- In late 1980s, I participated to VC at STScI
- In 1993, RG invited to VC of Service d'astrophysique, at Saclay. In the end, he did not come.
- In 1997, he came, by then I was Director of Basic Research at CEA and I had invited him. « What is your mission? »
- I participated in the ESO VC in the first half of 1996 and the first half of 1998.
- In December 1998, I was appointed successor of Riccardo. He left ESO end of June 1999, going straight to the position of AUI President, and I started September 1st.

5 March 1999

Official inauguration of Paranal Observatory, one telescope with two instruments, FORS and ISAAC

VLT Inauguration, March 1999, RG with President Eduardo Frei Ruiz-Tagle

(Speech by Carlo Rubbia)

March 1999: the ESO Council visits the ALMA site, Llano de Chajnantor.
I participated, as next designated DG.

In Munich, we occupied the appartment previously rented by RG. As a welcome present, he left us the a painting which he had produced, copying from Max Coyer

ALMA

Regular meetings as members of Alma Coordinating Committee, then of ALMA Board after bilateral project signed by Rita Colwell and CC in February 2003.
We broadly agreed on all the important issues, e.g. with practically every detail of our first bilateral ALMA plan, on the governance, on enhancing the power of the ALMA central team, and even on the choice of the leaders we put in place. But we had disagreements on several lesser issues, so that he would say to me: “I respectfully disagree!”.
Examples: early science, ALMA TAC.

Japan joining ALMA

First visit to Tokyo by an ALMA delegation, 28 to 30 September 1999, With RG (AUI), CC (ESO).
Visit to the Ministry, complete failure.
Common work continued.
Our Japanese colleagues obtained the agreement of their government in 2004, and were in the end the first to deliver antennas to the project

Signature ALMA tripartite agreement, September 2004
Robert Eisenstein, CC, Norio Kaifu

Meeting of ALMA Coordinating Committee.
Lunch at ESO Guest House in Santiago in 2002.

photos by Ishiguro-san

Nobel prize in physics, 2002

…and for me, an unforgettable dinner which he offered me in Santiago

ALMA groundbreaking, November 6 2003

ALMA Goundbreaking,

Robert Dickman,
Eduardo Hardy,
Fred Lo,
Massimo
Tarenghi,
CC,
Daniel Hofstadt

2002, 40 years ESO: comments from past DG

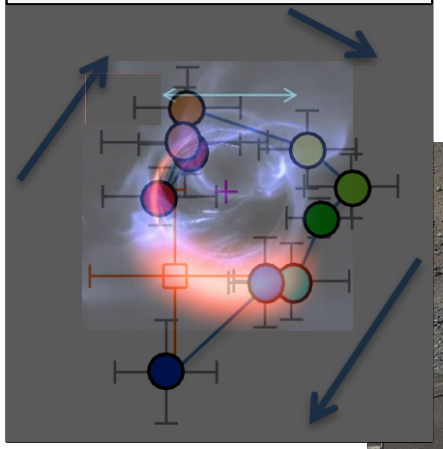
RICCARDO GIACCONI, ESO Director General, 1993–1999

I feel privileged in having had the opportunity to lead ESO during a period of great innovation and expansion. Building on thirty years of heritage, working together with an extremely competent staff and with the full support and cooperation of the ESO member states, we were successful in many endeavours. They include the construction of the Very Large Telescope and the development of Paranal, the modernization of the La Silla Telescopes, the introduction of new managerial and scientific methodology, the expansion of the Education and Public Outreach programmes and the start of the VLT interferometry development. By achieving success in all these areas we established ESO as a model for optical ground-based facilities around the world and redefined the role of ESO in European astronomy.

Today ESO is busily proceeding in the scientific exploitation of the VLT, in completing development of VLTI and is cooperating on a 50/50 basis with the US and Canada on the Atacama Large Millimeter Array, the largest ground-based astronomy programme yet undertaken. I am confident that ESO can lead an international cooperative effort on the next-generation overwhelmingly large telescope (OWL).

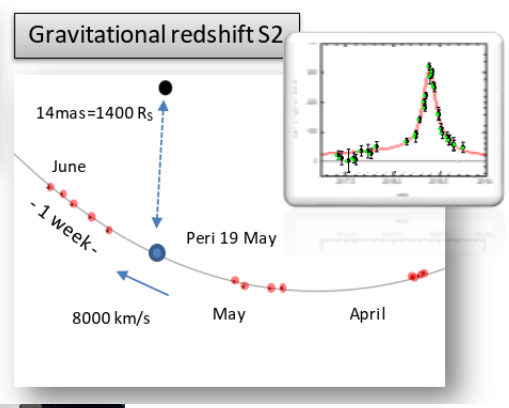
Looking at the Galactic Center at the event horizon scale with VLTI/GRAVITY

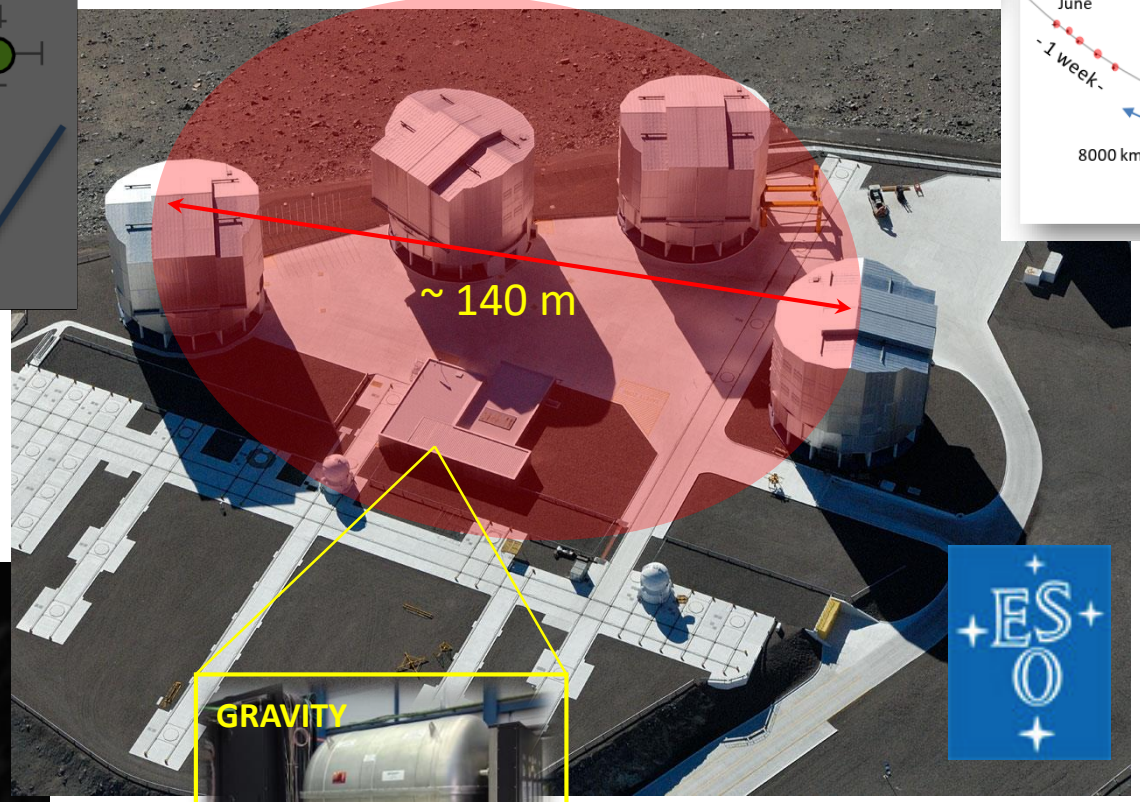
Constraint on the size of the event horizon with a flare orbit

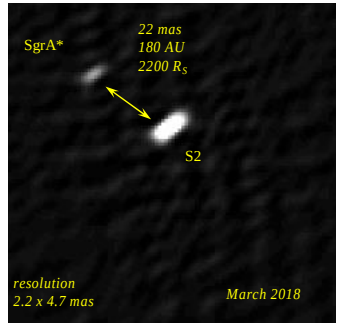


Angular resolution: 3 mas @ 2.2 µm
Astrometric accuracy: 10 µas @ 2.2 µm

Gravitational redshift S2







Last meeting

I think the last time we met was in Munich, where he had come with Mirella in 2006 or 2007. He did not like to delve into memories, he did not want to visit ESO, or our apartment. We just met him and Mirella in a café, with my husband Diego, and had an excellent time. We exchanged warm, personal Christmas cards for several years, long after I had left ESO.

- I am sad not to meet him again, but happy and proud to have known him.