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Pulsars: The Chronometers of the Universe

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Abstract. I consider the birth of gamma-ray astronomy in Palermo, and the first contacts of Nichi with pulsars within the COSB collaboration. Through the interaction with the Bologna and Parkes groups, Nichi became a leading personality in pulsar Astrophysics. In connection with the establishment of the Sardinian Radio Telescope, a group focused in pulsars was initiated by Nichi in Cagliari. I report my view of the future of the field, which I consider to be in Nichi's perspective.

Key words. gamma-ray astronomy; pulsars.

1. The birth of gamma-ray astronomy and pulsars

The detection of MeV-GeV gamma-rays of astrophysical interest is strictly related to that of the electron component of cosmic rays, since both are the constituents of electromagnetic showers. It is therefore natural that the Milan group of G. Occhialini, C. Dilworth, and L. Scarsi, which in collaboration with the Saclay group, had pioneered the study of cosmic electrons in Europe (see e.g. Agrinier et al. 1965) moved to gamma astronomy.

That was in the late sixties, and an important evolution of the collaboration was the transfer from Milan to the University of Palermo. Scarsi's choice was possibly in part motivated by the illustrious predecessor in Palermo, Bruno Rossi who was a great friend of Scarsi and Occhialini.

The first gamma-ray observations of Milan-Saclay-Palermo collaboration were on a balloon borne detector (a spark chamber). The obvious target was the Crab Nebula, that at the time was the reference source of all high energy astrophysical phenomena. In 1968 radio-pulsars were discovered, which immediately appeared as a real wonder of the sky, being identified with the until then mythical neutron stars, predicted in the thirties by Landau and Oppenheimer. Pulsars turned out to be the extremely precise astronomical clocks, comparable or superior to the most advanced laboratory atomic clocks. The discovery of a pulsar inside the Crab Nebula, detected also in the optical and X-rays, made the choice of that target in gamma rays rather straightforward. The photons expected from the source were not more than a few dozen, and they direction could be reconstructed within few degrees: the pulsar timing could be the direct signature of the gamma ray source. And indeed the Crab Nebula pulsar was the first source discovered in the gamma ray band (see Leray, J. P. et al. 1972).

A further step to the establishment of gamma-ray astronomy, came with SASII (1973) and COSB (1975-82) respectively an American and European mission. The first well recognized galactic sources were the two pul-

sars inside the young supernova remnant Crab and Vela, plus the enigmatic Geminga, which later turned out to be also a young pulsar.

It is in this contest that Nichi D'Amico initiated his scientific career in the late seventies in Palermo, within the highly successful COSB collaboration, and entered into the enchanted world of pulsar Astrophysics. In November 2005 the prestigious 13th Targa Giuseppe Piazzi was conferred to Nichi and his speech was "Gli orologi dell'universo: le pulsar".

2. From the gamma-rays to the radio band

The interests of Nichi are now shifting specifically to pulsar astrophysics, and he starts the collaboration with the Bologna radio-astronomy group, the main group in the field in Italy, which after the discovery of the first pulsar in Cambridge, had contributed with a number of important independent observations (pulsars with the B-label).

The next move has been the starting of the collaboration with Parkes in Australia, one of the most prominent group in pulsar Astrophysics, and certainly the leading one in the Southern hemisphere, with the non negligible advantage of the capability of observing the Milky Way.

Various contributions in this memorial describe the impressive achievements of Nichi within that collaboration, which range from new surveys, to detailed studies of pulsars in globular clusters, to pulsars in binaries, a theme I elaborate in the next section.

3. The new group in Cagliari

The next phase of Nichi career is founding a group in Cagliari, whose basic interest was (and is) Pulsar Astrophysics. The choice of Cagliari was obviously motivated by the construction of the Sardinian Radio Telescope and the decision of accepting a professorship at the university of Cagliari opened of the local academic interests and activity to Astrophysics.

The new group of Nichi, with Marta Burgay and Andrea Possenti and in collaboration with Parkes, became the main actor of the study of the binary pulsar system PSR J0737-3039 (Burgay et al. 2003). This is an ideal laboratory for testing and constraining General Relativity (G.R.). In this binary both components are pulsars. It represents a step forward, with respect to the other binary pulsar system PSR B1913+16, which permitted to Hulse and Taylor to demonstrate the production of gravitational waves, and to win the Nobel prize.

The Cagliari group, which egregiously represents the continuation and development of Nichi vision of pulsar physics, is now well established in a world scale. Its strength at least in part, is due to its opening to a large number of collaborations, which is certainly a legacy of Nichi attitude

4. What to expect and hope from pulsars in the future, which Nichi would be happy to see happening

I'll try to give my answers to the question, clarifying that I am not a pulsar specialist, but rather a witness of the wonders that pulsars have produced.

As mentioned above, being such formidable chronometers pulsar binaries can constrain GR, the observational constraints becoming more severe with the accumulation of pulsar data for decades. The obvious aim, seldom openly declared, is to find violations of GR towards a more advanced theory of gravitation. The same data accumulation procedure is promising regarding the determination of equation of state of neutron stars, the form of their magnetization and its evolution.

Pulsars as exceptionally stable chronometers, are natural detectors of gravitational waves. This is an old idea circulating already immediately after the pulsar discovery, that in the last years has demonstrated its feasibility, through the various Pulsar Transient Arrays. They monitor an ensemble of super stable pulsars, and aim to detect transient delays induced by the gravitational waves. They will possibly contribute to basic cosmological issues, like the importance of gravitational waves in the first epochs of the Universe.

The realm of pulsar astrophysics is potentially significantly enlarged by the discovery of pulsars as transients, i.e. as sources behaving like pulsars on very short time scales (say seconds) and for the rest remaining silent (Fast Transient Radio Pulsars). Their discovery depends on the advance of coherent dispersion techniques. In a way this is the entering of pulsar in the so called Time Domain Astrophysics, which is a magic word in the present specialist jargon.

The phenomenon is possibly related to that of fast radio bursts (FRB). This was started by the remarkable discovery by Lorimer et al. (2007), and should be considered as a by-product of pulsar research. I repute FRB on of the most important discoveries in Astrophysics in the last decades, with the probable connection with magnetar, and at least some classes of gamma-ray bursts. The radio to high energy connection, which was a basic factor in Nichi's scientific career, is once again recovered.

In its 53 years of history pulsar research has been a most successful sector of Astrophysics. Since its beginning it has required modest financial investments, a characteristics that has been maintained. Were it possible to quantify scientific progress per money spent (a challenging program for a PhD in Economy), I am sure that the field would excel, something which should be taken into account when the costs of basic research in Physics tend to diverge.

References

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