THE COMMON PROPERTIES OF PLERIONS AND ACTIVE GALACTIC NUCLEI

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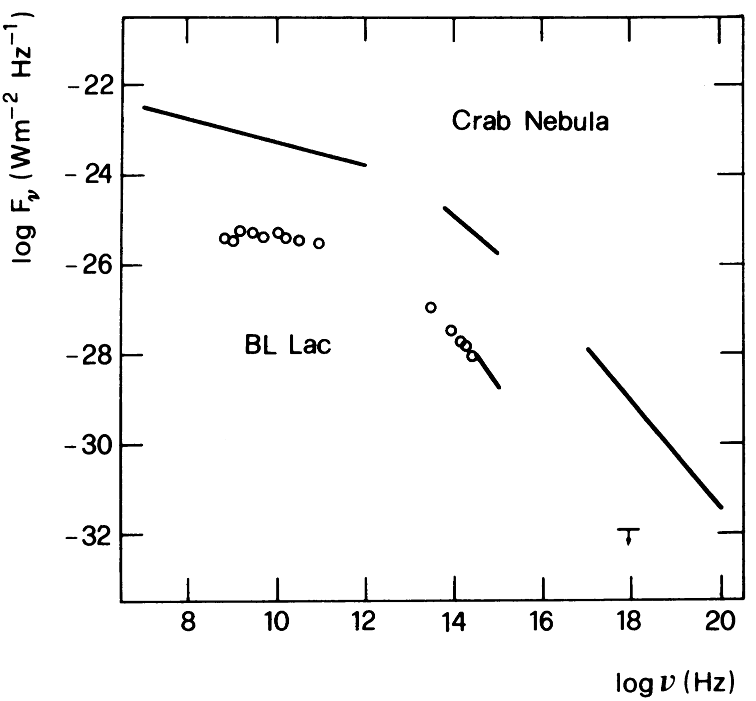
Plerions, i.e. supernova remnants resembling the Crab Nebula, are characterized at radio wavelengths by having: 1) a centrally peaked brightness distribution, 2) flat radio spectrum ($\alpha > -0.3$, $S_\nu \propto \nu^\alpha$), 3) high linear polarization, and 4) a highly ordered magnetic field (Weiler and Panagia, 1978, 1980). At higher frequencies (10^{11}-10^{13} Hz depending upon the age) the spectrum turns over and attains a slope of $\alpha \sim -1$. In particular, for the Crab Nebula the turnover frequency



Electromagnetic spectra of the Crab Nebula (upper curve) and BL Lacertae (lower curve).

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occurs at $\nu_c \sim 3\times10^{12}$ Hz (cf. Fig. 1). Moreover, the optical spectrum displays a slope of -0.9 and the radiation is linearly polarized. Non-thermal emission is also detected in the X-ray and γ-ray domains (Fig.1). Similar spectral characteristics are found for other bona fide plerions. As discussed by Weiler and Panagia (1980), the plerion phenomenon is determined by the presence of a highly energetic and active central object (a fast spinning neutron star) which is able to both accelerate and inject continuously relativistic electrons into the remnant with a typically flat energy distribution roughly proportional to E^{-1}.

It is interesting that this picture, which was originally devised to explain the properties and the evolution of plerions, can apply equally well to the case of compact nuclei in many extragalactic radio sources. In fact, we can recall that BL Lacertae objects are characterized by having, in addition to variability, a flat radio spectrum, steep optical and X-ray spectra (cf. Fig.1) and high integrated linear polarization at high radio frequencies and possibly in the visual. Similar properties are also found for the compact cores of extragalactic radio sources, which indeed may be different from BL Lac objects only in the fact that the latter ones are the "naked" version of the former ones (cf. Weiler and Johnston, 1980). The close similarity between plerions on the one side and BL Lac sources, as well as active nuclei, on the other side suggests the operation of comparable energy supply mechanisms in both classes, i.e. efficient conversion of rotational (as in the Crab pulsar) and/or gravitational (as may be the case of W50 - SS433) energy into relativistic electrons and magnetic fields, on vastly different scales. The properties of compactness and activity of the source then determine the characteristic acceleration process which is inherent to the source in that it must occur at, or very near to, the source itself and is independent of the conditions of the surrounding medium. We note that this would provide a more natural explanation for the flat radio spectrum of compact extragalactic radio sources than the presently accepted idea of "onion" layers of synchrotron self-absorbed components.

In conclusion, it appears that two types of acceleration processes are present in non-thermal sources:

a) A plerion-type mechanism which takes place in compact sources. It is essentially the same phenomenon at all scales and produces an electron spectrum $N(E) \propto E^{-1}$. This mechanism operates in plerions and compact nuclei of extragalactic sources.

b) A second acceleration process arises from the interaction of relatively low energy plasma with a large scale ambient medium. This process, which produces steep energy spectra $N(E) \propto E^{-2} - E^{-3}$, operates in shell type SNR and big lobes of extragalactic sources.

References

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