RADIO HALOES AROUND GALAXIES AND IN CLUSTERS

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The question of whether or not our and other normal galaxies have some sort of halo - an extended region containing, in particular, cosmic rays - has been discussed for no less than 25 years. Such a "cosmic ray halo" (CRH) appears as a radio-halo, although the absence of the latter is not evidence against the presence of CRH. The point is that the relativistic electrons responsible for the radio emission from the radio-halo undergo synchrotron and Compton losses which are practically absent in the case of the cosmic-ray proton-nuclear component. Possibly because the discussion concerning the existence of the radio-halo in the Galaxy has lasted for years it has acquired a particular character. The latter is clearly reflected in the report by Baldwin (1976) who emphasized that: "In this discussion so far I have avoided the use of the phrase "radio-halo". It arouses antagonism in otherwise placid astronomers and many sought to deny its existence..." Such a situation evidently reflects the difficulties that arise in detecting the radio-halo of our own Galaxy when account is taken of other confusing galactic sources as well as of the metagalactic background.

I have always considered the existence of some CRH and, probably, radio-halo to be most probable if not inevitable. This point of view was based on dynamical considerations as well as on radio-data while the objections to the existence of a radio-halo, to say nothing of a CRH, seemed quite unconvincing (Ginzburg and Syrovatskii 1964, Ginzburg 1967, also literature cited in Baldwin 1976, Ginzburg and Syrovatskii 1964, Ginzburg 1967, and Ginzburg and Ptuskin 1976). Clear proof based on observations and convincing interpretations of the data were needed. In my opinion such proofs have been obtained and to show this is the aim of the present remark. I mean, first of all, discussion of radio-astronomical data for our Galaxy which gives evidence in favour of the existence of a radio-halo with characteristic dimension $R \sim 10$ kpc and with a rather high luminosity (Bulanov et al. 1976 and Ginzburg & Ptuskin 1976).*

*Note also that in the radio-disk model used the half-thickness of the radio-disk is assumed in Baldwin (1976) to be equal to 750 pc which exceeds considerably the value accepted before, to say nothing of the half-thickness of the gaseous disk.

M. S. Longair and J. Einasto (eds.), The Large Scale Structure of the Universe, 161-163.

More obvious and in a certain sense more convincing are the radio-data for the "on edge" galaxies NGC 4631 (Ekers and Sancisi 1977) and NGC 891 (Allen et al. 1977; some data about this galaxy were presented already in Baldwin 1976). Since NGC 891 resembles our Galaxy, the fact that it has a radio-halo with a characteristic dimension of the order of 10 kpc (or if we take the distance from the galactic plane at which the radio-brightness at a wavelength of about 50 cm is half, then with a dimension of 4-5 kpc) is rather weighty additional proof in favour of the presence of approximately the same type of radio-halo around our Galaxy. Note that not a single case is known in which a galaxy with a rather bright radio-disk component was lacking a radio-halo. If the disk has low brightness in the radio band, this simply indicates the absence of sufficiently powerful sources of cosmic rays (or, more precisely, of their electron component). What may account for such a situation is another question not connected directly with the halo problem (the most natural explanation is that in a radio-quiet galaxy supernovae are anomalously rare, which in turn requires explanation).

The data on cosmic rays and in particular on the existence of the radioactive isotope ^{10}Be does not in the least contradict the existence of a galactic CRH; the opposite opinion expressed in the literature appeared to be due to a misunderstanding (Ginzburg and Ptuskin 1976, Ginzburg 1977). Moreover, recent data on the amount of ^{10}Be indicates a rather rapid cosmic-ray outflow from the region of the gaseous disk, where the main sources are concentrated. Further developments of the techniques of cosmic-ray isotopic analysis as well as the use of gamma-ray data (Ginzburg 1977) may supplement the radio method for studies of the Galactic CRH in important ways.

Thus, there is now every reason to believe that cosmic rays are not trapped near the galactic plane but escape from the gaseous disk and form a CRH which results naturally in the appearance of a radio-halo. Further observations and the corresponding theoretical analysis of various relevant problems must be aimed at,in particular a clarification of the character of CRH transition into intergalactic space. One may think that this transition, at least quantitatively, is not universal but depends on the type of the cluster to which a given galaxy belongs. For sufficiently dense and large clusters it is quite possible that the CRH and even radio-halo of some galaxies lose their individuality and cosmic rays fill all the cluster with an increased intensity. Then, naturally, a cosmic-ray halo (CRH) and, in principle, a radio-halo must be formed for the whole cluster and not for each galaxy.

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DISCUSSION

Valentijn: Is there according to your calculations in situ particle acceleration needed to explain the observed spectral index distribution of galactic haloes?

Ginzburg: Those computations which I mentioned have been carried out under the assumption that the sources of relativistic electrons are within the disk. Electrons will diffuse into the halo and will lose their energy (in particular, through radio emission). Evidence about the conditions existing in the halo of the Galaxy and of other normal galaxies give us no foundation for expecting any effective acceleration in these regions. Nevertheless, it is quite possible to imagine conditions in which it would be necessary to consider the acceleration of electrons in haloes or in clusters of galaxies.

Ostriker: In rich spiral clusters, electron cosmic rays will diffuse from the disks of galaxies into their radio haloes, and from these into the general intergalactic cluster space thereby producing a cluster radio halo. Has anyone in your group computed the expected properties of such cluster haloes?

Ginsburg: No. Nobody in our group has so far done it. However these computations need to be done and I hope that they will be done. Certainly it will be necessary to specify a great number of parameters (characteristics such as the halo of clusters, sizes of haloes, radio luminosity, spectral index, etc., which obviously will depend on the type of the cluster, the magnetic field between galaxies, etc.).

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