GENERAL DISCUSSION

A.W. WOLFENDALE

This question of the contribution of discrete sources to the gamma ray flux is an important one, of course. Now, it seems to me that is dangerous to compare the situation in gamma rays with that in X-rays. You (Prof. Setti) are quite right that in the X-ray region the vast majority of the flux is due to discrete sources, but, I think, that in the gamma rays you should really compare more with the electron situation and there, of course, we know from synchroton data,which tell us something about the way electrons are distributed, that the bulk of the radiation comes from the continuum of the electrons moving in the interstellar magnetic field so that the contribution from discrete sources there is small. However, to look at perhaps the more important point of gradients. I may, perhaps, be allowed just to show this transparency again (Fig. 4, pg. 313, this volume). I think that what you want to do is to put a horizontal line through here (fig. on the left, E_γ > 100 MeV). Now, the point is that the local value has an uncertainty on it. This uncertainty, as shown, comes from the high-latitude gamma ray data, where one tries to determine the flux in that way. There's a point of, I think, better accuracy that one could draw there from our knowledge of the local proton spectrum, the local electron spectrum aligned with an enhancement as mentioned by you to fit in with radio, and our knowledge of nuclear physics. In other words, I think you have got to make your line go through there without any movement up and down, and, I think, it's stretching things a bit to get it quite flat, to have no gradient at all in that region. Coming to the other diagram (E_γ: 35-100 MeV), I think you would agree that it is very hard to get that to be flat, and I think one is really forced to the conclusion, with which you may agree, that the electrons show a gradient. But, I think it is true to say that within perhaps a matter of months there will be sufficient data from COS B to firm up these points, and particularly if we can get them at higher energies where the proton contribution is bigger and, if then, we really do see points with fairly highprecision falling down like that, I think we will be safe, because the only flaw that you would make then, I think, is that we have underestimated the contribution from the discrete sources. If that is so, the point relative to the local value won't move, while those toward the galactic anticenter will come down even lower, so the gradient out there would be steeper. Here you have a problem because the point toward the galactic center will come down as well, but then, I think, it would mean that the target material is uncertain, the point being that in this region we are at the mercy of what happens in molecular clouds, how many there are, what their den-

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sities are, and so on. In the outer galaxy region the contribution of molecular clouds is very, very small. It's all nice neutral hydrogen, decently distributed, so I really do think that one would be able to say something in that region.

V.L. GINZBURG

There are four principal aspects related to the problem of the origin of cosmic rays, I mean the origin of the main part of cosmic rays observed near the Earth.

1) Galactic versus metegalactic origin. It has been clear for about 30 years that the galactic model is correct. The corresponding energetic and dynamical arguments are quite strong and are becoming even stronger. γ-ray observations can provide direct proof and to some extent this proof already exists. New observations are needed (see Wolfendale, this symposium). But I do not see any real danger of a change here.

2) Halo versus disk galactic origin models. I wrote about this so many times that I shall not discuss it again (see references in my paper at this Conference). My opinion is that the problem is clear enough in favour of the halo model, especially due to radioastronomical observations of edge-on galaxies (see Sancisi's paper at this Conference).

3) Mixing problem. The question is whether,after subtraction of local sources, such as SN envelopes, etc., the energy density of cosmic rays, and particularly of the electronic component, is rather uniform or not over a large region of quasi-ellipsoidal shape and typical semi-major axis 10 to 14 Kpc and semi-minor axis 3 to 10 Kpc. I used to think, and still do, that the answer is affirmative. But the question is not clear. It must be analyzed carefully, and mainly by means of radio and gamma-ray astronomical methods.

4) Sources of cosmic rays, places of acceleration, mechanisms of acceleration. These are old problems, but they are the hottest at the moment. The main competing possibilities are: a) acceleration inside young supernovae envelopes, b) acceleration by shocks from supernovæ in low-density interstellar medium, c) acceleration by other stars. I believe in a), but b) is now the most controversial possibility. From the talks and remarks by Axford, by Forman and by Völk we can conclude, as far as I understand, that acceleration in the interstellar medium can be effective enough only if in the shock region a sheet automatically appears with a diffusion coefficient D much smaller than the average for the halo model ($D_{eff} \sim 10^{28} - 10^{29} cm^2 s^{-1}$). In such a case, as Axford emphasized in his talk, acceleration can be effective even in the halo when the shock wave reaches there. But this means "in situ" accleration in the halo. In the past this possibility has been usually disregarded. For instance when I discussed the diffusive or "convective" propagation in the halo (see Proceedings of the Kyoto Conference, Vol. 2, page 148, 1979) I also neglected the "in situ" acceleration. The presence of such "in situ" acceleration would change the distribution of the brightness of radio continuum radiation with distance from the galactic plane at different frequencies. Therefore, from this point of view, the continuation of the radio observations of galaxies seen edge-on as

described by Sancisi in his paper at this symposium is especially needed.

R. COWSIK

I want to make a few points. Number one, regarding acceleration. All the mechanisms of acceleration we have so far discussed need an injection mechanism, that is, need a source of particles which are of higher energy. Then they will collide with matter, that is, they will collide with bulk motions, and this problem has not been understood at all. It is one of the most important problems to understand in terms of totally understanding the acceleration process. The second point I would like to make is that when we talk about the origin of cosmic rays we should also try to understand the origin of the cosmic ray electrons including the highest-energy ones, like those measured by Nishimura and those by Meyer and co-workers at Chicago. If we put the sources of cosmic rays very far away, we would not be able to get the highest energy electrons. The typical distances that are compared by the present measurements are of the order of a couple of hundred parsecs, purely from content losses on the 3°K background and the synchroton radiation in the galaxy. The third point that I would like to make is that Fermi-type or any stochastic type of acceleration in the region where the secondaries are also propagating, is precluded by the observation of the relative spectrum of secondaries and primaries. That is, it is precluded by the measurement of lithium-to-carbon ratio as a function of energy. These are the only three points that I wanted to make.

J. LINSLEY

When I was speaking a couple of days ago, I tried to make a point that the highest-energy cosmic rays, those with energies extending up to 10^{20} eV are certainly entitled to be considered cosmic, they are the most cosmic, in fact, of all. They have, to the highest degree, the properties that drew attention to cosmic rays in the first place and I have to say that we now have definite evidence on the properties of these experimental results, and these results are not explained, so that highest energy cosmic rays are still a mystery. Their acceleration is not explained and their propagation is not explained and it's not known for sure what part of the universe they fill and I want to comment that until this part of the cosmic rays is understood I think we can have no confidence in the explanations of the low energy. We can never be sure that the same discovery that explains the highest-energy cosmic rays will not overturn our provisional explanations and understanding of the properties of the low-energy cosmic rays.

G. SETTI

I feel I should intervene at this moment, because a number of arguments brought into the discussion are directly related to the remarks I made previously and, therefore, some clarification is in order. First of all, I wish to come back to this question of the gradient of cosmic rays illustrated again by Prof. Wolfendale. Quite generally I believe it is very dangerous to show diagrams with lines drawn on them because of very well known optical effects. More specifically, looking at your figure with $E_\gamma > 100$, if only the points were marked then I remain of the opinion that a horizontal line would fit them perfectly well, particularly in view of the fact that the last point is very uncertain. Concerning the diagram with $E_\gamma \simeq 35 - 100$ MeV, there I would agree that the points in the direction of the anticenter appear much lower than the average of the points in the direction of the galactic center. But, as you say, this diagram may be more relevant for the distribution of the electrons and it may, therefore, fit in more properly with the general question of the constancy of the proton to electron ratio. In any case, it seems to me, still, that before one can reach firm conclusions on this subject, the problem of the contribution of localized sources to the galactic γ-ray background must be fully settled. Coming now to some of the remarks made by Prof. Ginzburg, first of all, I think that the existence of a halo in our galaxy is fairly uncertain and that it is very doubtful if one can invoke some positive detections of haloes in external galaxies to prove anything with regard to our own galaxy. But I do not wish to repeat what I have already said in my concluding remarks. I think that the real important point, about which all of us may agree, is that particles must get out of galaxies and that one wishes to better understand how these particles diffuse outward, or are convected outward. One uses different names because, of course, one doesn't know the answer to this basic question. Concerning the question of the origin of cosmic rays I wish to make it clear that I am not advocating an extra-galactic origin for the bulk energy of the cosmic rays. The only thing I wanted to point out is that as yet, I do not see any compelling argument that makes this hypothesis unacceptable and that, therefore, this matter must be settled by observations rather than by beliefs.

J. WDOWCZYK

I was expecting that Prof. Ginzburg would cover this topic in his remarks, but he did not. I have taken the liberty to make a few remarks on the point of the Magellanic Clouds and I should be glad to be corrected if I am wrong: it concerns Prof. Setti's remark about whether the test of the Magellanic Clouds is conclusive for the origin, galactic or extragalactic, of the cosmic rays. Well, if I have not misunderstood the logic behind that topic, it seems that it is an argument that works in one way and not in two ways, in the sense that if we do see with the next generation gamma ray experiments that there is a finite gamma ray flux of the order of 10^{-7} ph/cm^{2}s, this does not necessarily mean that the cosmic rays are extragalactic because there can be sources in the Magellanic Clouds. However, if we do not see them then this is a clear indication that the cosmic rays are not extragalactic. If we take into consideration what the boundary conditions of this argument are, I think that this test is, in a certain sense, conclusive about the origin.

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J. LINSLEY

The question of the existence of a halo is certainly interesting in connection with highest-energy cosmic rays because it makes a difference for understanding anisotropy in this galaxy, and also for models that would involve scattering by galaxies. So, it is an interesting question.

J. NISHIMURA

May I make some remarks about the different ratios of electrons to protons. Prof. Setti mentioned that one expects a very large magnetic field if one takes the electron spectrum observed at the earth. But, in fact, the electrons concern the energy of several hundred MeV, and at this energy, solar modulation is very high; as Prof. Wolfendale mentioned, the intensity could increase two or three times more. Besides, the synchroton radiation depends on the square of the magnetic field. So, one would expect a magnetic field of several μ-gauss. Of course, the electron to proton ratio may change, but the above argument may not be taken to stress that there is a different electron to proton ratio. Another point, which I want to ask Prof. Ginzburg, is that you mentioned that in the halo there is a change of the spectral index, but in that case the magnetic field may change with altitude so that it may affect also . . .

V.L. GINZBURG

Yes, the problem would be more complicated.

P. KIRALY

Well, about the question of galactic vs. extra-galactic origin in the low energy region, I would say that anisotropy results between 10^{11} and 10^{14}eV give a fairly certain result, and one can be fairly confident that it is due to galactic origin. Now, there may be some question of galactic interstellar acceleration which might give rise to some anisotropy. But it is rather an unlikely scenario that one has an extra-galactic origin and a substantial galactic acceleration causing anisotropy in the low energy region.

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