Universal Cosmic Rays and Harrison's Inhomogeneity Postulate

PETER D. NOERDLINGER*
Department of Physics and Astronomy, University of Iowa, Iowa City, Iowa 52240
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Cosmologies of the type suggested by Harrison, in which initial baryon inhomogeneity leads to the formation of galaxies, are shown to preclude the possibility that the bulk of cosmic rays are universal.

THE postulate has recently been introduced by Harrison[1] that the distribution of baryon-number in the universe was primordially inhomogeneous. Thus, when the temperature fell sufficiently to favor annihilation, local excesses of baryons (or antibaryons) remained, of sufficient size to condense into galaxies under the influence of gravitation. While no upper limit was given for the size region that is supposed to evolve into a pure baryon or antibaryon condensation, the model seems to lead to regions not much larger than a galaxy, for two reasons. On the one hand, it is necessary to assume inhomogeneities larger than expected on a random basis, and the larger the region, the more radical is the assumption. On the other hand, it is intended that the gravitational contraction of a typical region lead to the formation of a galaxy. In fact, Harrison explicitly refers[2] to the possible existence of condensations or blobs of antimatter within matter galaxies, and conversely. The postulate that baryon inhomogeneity leads to galaxy formation seems attractive, because it requires less by way of assumed initial inhomogeneity amplitude than theories based on primordial density inhomogeneity. We therefore explore the consequences of the theory in the realm of cosmic rays.

It is an open question[3,4] whether cosmic rays are mainly of galactic or extragalactic origin. Discounting solar particles and galactic cosmic rays below 1 GeV, whose spectrum is ill-determined, more than 90% of all cosmic rays are in the energy range[5] 1.0–10.0 GeV. In view of the smoothness[6] of the spectrum from 1.0 to 10^6 GeV, one would expect a common source throughout this range as well, although this argument is not conclusive. In any case, in the sequel a "universal" theory of cosmic rays will refer to a theory in which most of the particles in the energy range 1.0–10.0 GeV are of extragalactic origin. It is possible to show that a universal theory of cosmic rays is ruled out in Harrison's cosmology. In a universal theory, it must be assumed that a negligible fraction of cosmic rays come from normal galaxies.[7] Therefore, the majority of cosmic rays in our galaxy would have to have come from other sources, and have diffused into the galaxy. The time of generation could well have been as early as 5×10^8 yr after the primordial fireball.[8] The earlier the time of generation, the more chance cosmic rays from antimatter regions have had to diffuse to us. But since our own galaxy must be a negligible source in a universal-cosmic-ray theory, it is unavoidable that cosmic rays must have diffused into our galaxy from sources *at least* as distant as the few nearest galaxies, $\sim$0.5 megaparsec (Mpc). Now, whatever the source of cosmic rays, in Harrison's cosmology they must produce roughly equal numbers of particles and antiparticles, when averaged over a few galaxies. But it has been shown experimentally that cosmic rays contain less than 0.1% antiprotons[9] and that the ratio of antinulcei to nuclei for $Z>2$ is less than 0.1%.[10] Therefore, if Harrison's postulate holds, almost all cosmic rays of energy >1.0 GeV are of galactic origin.

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* Present address: New Mexico Institute of Mining and Technology, Socorro, New Mexico 87801.

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