

# Cosmic Rays : Perspectives for the Future

Arnold Wolfendale

## 1. INTRODUCTION

This paper is a brief summary of my views about the future of our subject, and my pleas for certain improvements.

The first plea – and perspective – relates to the need for ‘lateral thinking’, i.e. the need to examine related areas of science. Rarely, does a result in Cosmic Ray Physics represent the end-product; usually, information is needed from Astronomy, Geophysics or Particle Physics before a result can be fully appreciated.

The second plea is for rather more effort to be directed towards solar-terrestrial relations. It is evident that, with the onset of Climate Change, such studies – of which low energy cosmic rays forms a part – have an important part to play. The various energy bands of cosmic rays (CR) will be considered in turn.

## 2. LOW ENERGIES

‘Cosmic Rays and Global Warming’ is an obvious growth area here. ‘Lateral thinking’ is certainly needed in this field. A typical topic concerns ‘clouds’, following the well-known demonstration of a strong correlation between the neutron-monitor count rate and low cloud cover. It is naïve to consider ‘clouds’ as a single entity; there are different types of clouds, each with its own sensitivity to CR - , or CR-related, effects. The manner in which CR-induced changes affect clouds (e.g. height – and width – dependence) and in turn influence the measured quantity (the ‘cloud cover’), will also need to be addressed. This area is of crucial importance.

Turning to the passage of space – probes through the termination shock, the determination of the holy grail of low energy CR is in sight; this is the inter-stellar spectrum, i.e. the ambient CR spectrum away from the perturbing effects of the solar system. Lateral thinking here requires attention to measurements of very local interstellar winds, ionized gas, magnetic fields, etc.

## 3. THE PEV REGION

The information content of the ‘knee’ in the energy spectrum at  $\sim 3\text{PeV}$  has still not been adequately tapped. Measurements are still showing a sharp knee, indeed some

A.W. Wolfendale is with the Physics Department, Durham University, Durham, UK).

knees are very sharp. A quantitative estimate of the magnitude of the sharpness (the second derivative of log intensity with respect to log energy) is still not being given by workers in the field. Its value, and interpretation, will be of considerable value in the on-going quest for the mechanism by which CR are accelerated.

## 4. THE ANKLE REGION AND ABOVE

Another important feature in the energy spectrum of primary CR is the well-known ‘ankle’ at about 10 EeV. The crucial question of the evidence for a transition from Galactic- to Extragalactic – origin is presumably tied up with this feature. Again, there is need for a quantitative determination of the sharpness. In turn, more detailed studies are necessary of the spectral shape expected for EG sources distributed in a realistic way both in terms of location, type and strength, together with information about the topography of the EG (and G) magnetic field. A major effort is necessary in this lateral-thinking-area if the considerable efforts involved in measuring the ultra-high energy CR properties are to be adequately rewarded.

Similarly, but perhaps at a more difficult level, the interaction models need more attention. AUGER results appear to show a conflict between the masses of primary CR beyond 1 EeV inferred from EAs depth of maximum results and those inferred from apparently coincident – in – position EG sources (AGN). Specifically, ‘heavy’ nuclei and protons respectively. Thus, we have a re-run of the situation at much lower energies of some decades ago. At that time, a change of interaction characteristics was postulated (scaling-breakdown) and that seemed to be partly true, at least. Caution is needed with the present ‘highest energy known to mankind’, however. Although the Scaling-breakdown model may well be still acceptable at the highest energy (T Wibig, this Symposium) the image of the subject for particle physics has been fragile in the past and we need to be sure to ‘get it right’.

## 5. CONCLUSIONS

The prognosis for our subject is very good, not least in the area of European efforts. It is also pleasing to note that the European Cosmic Ray Symposia continue to play a useful role.

After this superbly organized meeting in Kosice we look forward to the next meeting in Finland in 2010 and, very significantly, to honouring Viktor Hess, on the Centenary of his great discovery, in 2012.