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~~(The Significance of)~~ The International Geophysical Year & its Significance.

New Delhi

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We are all familiar with the property exhibited by a magnetized needle of tending ~~it~~ to take up the north south direction. History does not record how long ago this ~~observation~~ discovery was made. It was probably made in China and very long ago. But there is no doubt that centuries before Columbus began his famous voyages, this orientative property of the magnetic needle had been in use~~d~~ extensively ~~to~~ for guid~~e~~ing navigation. Columbus, presumably because of the wide range of his navigation, seems to have been the first to realize that the magnetic compass did not point true north, and that the deviation could be quite considerable in some places. There is a story told of an unusual experience of his during his first trans-atlantic voyage, namely that when the crew saw the compass needle pointing in a direction nearly 10° west of the true north as indicated by the pole star, they threatened to mutiny, as they were unwilling to navigate in strange waters where even the magnetic compass did not behave normally. The story further adds that Columbus shifted the compass card during the night without the crew's knowing it, so as to make ~~its~~ the behaviour of the compass appear normal, and this ~~avoided~~ the mutiny. [Incidentally I may mention that the deviation of the magnetic north from the geographic north is generally referred to ~~for convenience~~ as magnetic declination.

Halley, the great astronomer, whose name ~~is~~ is so familiar to us as the discoverer of the famous comet named after him, and who was in a large measure responsible for the publication of Newton's Princip~~le~~ia, was interested in many other subjects besides astronomy, and we owe to him the first detailed map of ~~the~~ magnetic declination over the earth. This map, which was first published in 1702, must have been the result of extensive world wide observations. Halley not only had fairly precise information regarding the declinations over many regions, both in the northern and the southern hemisperes — except over the Pacific ocean, which is understandable — but he was also aware that these declinations ~~were~~ varied continuously. The geophysicist refers to such a variation as secular variation~~s~~. What is even more ~~uncanny~~ remarkable is that Halley proposed an explanation for this secular variation which is as good as ~~the best alternative explanation, which~~ any that we can offer today.

The explanation is this. The inner core of the earth, which is still fluid, rotates with a slightly smaller speed than the hard outer shell or mantle. The difference in speed is very small, and corresponds to about 20° in a century. Halley estimated even this angle nearly correctly. If now the magnetic axis of the inner core does not coincide with that of the mantle, which may be presumed to be close to the geographic polar axis, the declination receives a natural explanation, as also its secular variation. We are indebted to Professor Bullard for having drawn attention to two remarkable papers of Halley published nearly three centuries ago, (in which these results are reported and) which had almost been forgotten by later generations of geophysicists.

The stimulus for the first world wide organization of collaborative magnetic observations probably came from the Great Mathematician Gauss, who will rank with Newton and Archimedes as one of the greatest mathematicians the world has ever produced. He also used these observations very effectively. Indeed he developed a powerful new technique for the analysis of the constants of the earth's magnetic field obtained from the different magnetic observatories. With the help of this new technique of analysis, which is now called harmonic analysis, he came to the conclusion that the bulk of the observed magnetic field of the earth, namely 94%, should definitely be attributed to causes inside the surface of the earth, and the remaining small part equally definitely to causes outside the earth's surface. Looking for probable causes outside the earth, he postulates the presence of electrically charged layers in the upper regions of the atmosphere, which by their movements produce this extra magnetic field. Since this conclusion is of great importance, I shall quote Gauss in his own words — I mean ofcourse in English translation. "If we seek for their immediate causes, partly or wholly, without the earth, and confine ourselves to known scientific grounds, we can only think of galvanic currents. But the atmosphere is no conductor of such currents, neither is vacant space; thus in seeking in the upper regions for a vehicle of galvanic currents we go beyond our knowledge. But our ignorance gives us no right absolutely to deny the possibility of such currents; we are forbidden to do so by the enigmatical phenomenon of the Aurora Borealis, in which there is every appearence that electricity in motion performs a principal part. It will therefore still be interesting to examine what ~~from~~ form magnetic action arising from such currents would assume on the surface of the earth".

We know today definitely that there are such electrically charged layers in the upper regions of the atmosphere, and it is the presence of these layers that renders all radio propagation over large distances on the surface of the earth possible. But what is uncanny in Gauss's prediction is this. His confidence in his technique of analysis, and in the reality of the small residual part of the earth's magnetism, which on this analysis has to be attributed to causes outside the earth's surface, was so firm that he had no hesitation in postulating the existence of such a charged layer, even though the then known dielectric properties of the atmosphere would not ~~normally~~ permit such charged layers. It is this confidence again that prompts him to find fresh evidence for the maintenance of such charges in the earth's atmosphere, and for invoking the aurora.

This casual invocation of the aurora by Gauss to justify the possibility of presence of a charged layer, which is needed to explain the small residue of the earth's magnetism that has to be attributed to causes outside the surface of the earth, turns out to be ~~of~~ much more significan~~ce~~t than Gauss ~~intended~~ imagined. The connection between the aurorae and the earth's magnetic field is indeed very close, and is of great topical interest to us in connection with the International Geophysical Year programmes.

Before I proceed further I should mention immediately that unlike the 94% of the earth's field, which is more or less permanent, the small residue that we are considering will show relatively large variations, diurnal and otherwise, and these variations have been studied extensively.

Coming back to the aurora , most of you know that we are now passing through a period of intense sunspot activity. The sunspot activity will soon reach a ~~maxim~~ maximum, if it has not reached it already, and will then gradually fade out, and then incraase again and reach a maximum again after about eleven years. In other words the sunspot activity is periodic, and ~~the~~ its natural period is about eleven years. Now during the period of intense activity there are many regions on the sun's surface that flare up and emit intense radiations in the extreme ultra violet and even soft x-ray region of the spectrum. These radiations naturally travel with the velocity of light, and therefore take only a short time, about 8 minutes to reach the earth. The X ~~se radiations~~ naturally produce a sharp increase in the ionization of the upper regions of the atmosphere, and therefore interfere with radio propagation. The occasional fade outs in radio reception are due to this cause.

Along with the emission of intense ultra violet and X-radiations from the disturbed regions of the sun's surface, there is also intense emission of highly energetic charged particles, which travel with velocities of the order of 2000 kilometres per second or even more; ~~occasionally~~ this is about a hundred and fiftieth of the velocity of light, and these particles will therefore take 150 times the time taken by light waves to reach the earth. Hence the charged particles will reach the earth about a day behind the ultra-violet radiations emanating from the same source of disturbance. These charged particles also ionize the atmosphere, but their effects on radio propagation will be spread over longer intervals of time than the effects of the radiations which produce the fade-out.

There is, however, one essential difference between the passage of radiations and of the charged particles. Whereas the former are not affected by the magnetic field of the earth, the latter will be greatly affected by this field. A charged particle will have to have enormously high energy to be able to reach the equator, whereas it can quite easily reach regions near the poles. In other words owing to the presence of this magnetic field there will be a marked concentration of streams of charged particles in the higher lattitudes than in the lower ones. The auroral displays are a natural concomitant of the entry of these charged streams into the earth's atmosphere, and the prevalence and concentration of these auroral displays in the polar regions therefore follow as a natural consequence. These brilliant auroral displays are indeed very impressive, and should therefore have excited wonder and curiosity since the very earliest times.

The first systematic study in the laboratory of the movements of charged particles in the neighbourhood of uniformly magnetized steel spheres, under conditions simulating those under which the charged particles from the sun enter the earth's atmosphere, were made by Birkeland, and he also organized systematic field observations on the aurorae. Since one is now dealing with a fleeting phenomenon, not only extensive observations are necessary, but also simultaneous observations that ~~which~~ are properly coordinated. This must have been the first attempt at simultaneous observations over extensive regions.

It is extremely significant (A) that Birkeland took a major part in organizing the first polar year programme, and (B) that ~~but~~ the study of the aurora~~e~~ and of the magnetic fields near the poles figured prominently in this programme. This was exactly 75 years ago, 1882-83 ~~and the Polar year was from 1882-83~~. Since the programme concerned itself with the polar regions, many other geophysical phenomena peculiar to these high latitudes were also included, particularly meteorological and oceanographic studies. The arctic region naturally attracted much more attention than the antarctic regions, since information available then regarding the antarctic regions was very meagre.

The success of the first polar year led to a repitition of it just 50 years later in 1932-33. The intense effort needed in the implementation of such a programme would not have permitted repitition at shorter intervals.

A phenomenon closely associated with the presence of charged particles in the atmosphere and with the auroral displays, would be the propagation of radiowaves in such regions. These ionospheric investigations, however, could not have been included in the first Polar year programme, since so little was known then about radio waves, and even the little that was known was confined to a few simple laboratory experiments on the production and detection of electro-magnetic waves. Ionospheric investigations also therefore figured prominently in the second polar year programme.

The current programme, coming 25 years after the 2nd Polar year, will naturally be much more extensive than either of the earlier ones, and would cover almost every aspect of geophysics. The year chosen for the intensive study of these phenomena will not be just a year, but considerably longer, and will approximately be called the geophysical year, instead of the polar year. I have merely to mention the major branches to impress on you the range of subjects in geophysics that will be covered. The major headings are: meteorology, geomagnetism, aurora and airglow, ionosphere, solar activity, cosmic rays, latitudes and longitudes, glaciology, oceanography, rockets and satellites, seismology, and gravity measurements.

Many of you might have heard of the International Council of Scientific Unions, which is shortly referred to as ICSU, which coordinates the work of the various international scientific unions. There are about thirteen such unions, and some of them, like the international Union of Geodesy and Geophysics, of which Dr K. R. Ramanathan of the Ahmedabad Physical Research Laboratory is now the President, the International Astronomical Union and the International Scientific Radio Union have several separate commissions. There are several joint and mixed commissions too. ICSU organizes through these Unions numerous scientific symposia every year on problems of live interest and sponsors other international scientific activities too. It also organizes directly special scientific programmes; and the International Geophysical prpgramme is one such, and is undoubtedly the most extensive programme that has ever been undertaken by an international organization. It also represents the greatest cooperative effort on a world-wide basis. As many as 70 countries are actively participating in this programme including India ofcourse. Even the mere enumeration of the institutions that would be engaged in this programme would cover a good sized book. All the various scientific organizations in the country, the observatories, the Universities, the Council of Scientific and Industrial Research, the scientific departments in the Ministry of Education and Scientific Research, Information and Broadcating, Communications and Defence are participating in the programme. A detailed account of the Indian programme, and the problems that the different organizations would take up, is given in a forty page bulletin issued recently by the Indian National Committee for the International Geophysical Year. Other bulletins also have been issued by this Committee, which deal with the details of implementation of specific items in the programme.

The bulletin referred to defines the basic philosophy underlying the formulation of the programme, and gives the following criteria for the selection of problems:

(a) Problems requiring concurrent synoptic observations at many points involving cooperative observations by many stations,

(b) problems of branches of the geophysical sciences whose solutions will be aided by the availability of synoptic or other concentrated work during the IGY in other geophysical sciences,

(c) observations of all major geophysical phenomena in relatively inaccessible regions of the Earth that can be occupied during the IGY because of the extraordinary effect during that interval in order to augment our basic knowledge of the Earth and the solar and other influences acting upon it,

(d) epochal observations of slowly varying terrestrial phenomena; to establish basic information for subsequent comparison at later epochs.

Elaborate arrangements are being made for receiving the observational data that would be collected during the Geophysical year, to publish them, and to make them available to the specialists working in the field. We are looking forward to a period of intense scientific activity, and we hope it will help us to solve at least some of the outstanding problems in Geophysics.