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Research by the Tasmanian cosmic ray group during the International Geophysical Year

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Abstract

Systematic recording of the cosmic radiation commenced in Hobart in 1946 and at Mawson in Antarctica in 1955, making these two of the longest running cosmic ray observatories in the world. For the IGY, observations were also made at a sub-Antarctic island and near the equator, and an airborne survey of the nucleonic component was made from Geomagnetic Latitude −60°, south of Australia, to Japan and back. At Hobart there were neutron monitors, vertical and inclined muon telescopes, an ionization chamber, and two muon telescopes at ~40 m of water equivalent underground. The research based on these and other observations determined the energy dependence of the Forbush and 11-year variations and concentrated, in particular, on understanding the anisotropic nature of galactic cosmic rays up to 150 GeV; the anisotropies in the onset phase of Forbush decreases; and the anisotropies in solar cosmic ray events. An investigation was initiated to calculate the trajectories and cutoff rigidities of cosmic rays in a high order simulation of the geomagnetic field. This was completed in 1959–60.

Keywords: Cosmic rays; International geophysical year; Neutron monitor; Meson telescope; Muon telescope; Asymptotic directions

1. Cosmic ray research before the IGY

Measurements of the ionization rate due to the cosmic radiation were made at the University of Tasmania in 1924 by A.L. McAulay using a 4.2 L ionization chamber. Between 1935 and 1940, A.R. Hogg operated a 4 L continuously recording ionization chamber at the Mt. Stromlo astronomical observatory (35.32°S, 149.01°E), near Canberra (A.G. Fenton in Duldig, 2000). Hogg used his data to study solar control of the 27-day and diurnal variations of the cosmic radiation. His diurnal variation results contributed to the world-wide set of data that led to the recognition of the twenty two year cycle in the phase of the diurnal variation discovered by Thambyahpillai and Elliot, 1953. Hogg's earliest data commenced soon after the commencement of solar cycle 17: re-examination of his records shows no evidence for ground level enhancements (GLEs) prior to those seen by Forbush (1946) in 1942.

The modern cosmic ray program commenced in Tasmania in 1946 with the construction of a twofold coincidence telescope using Geiger–Muller (GM) counters to measure the East–West asymmetry of the muon component at Hobart. In 1950 these measurements were extended to Macquarie Island, at a geomagnetic latitude reported at the time as being 61°S but now known to be 64°S. Fig. 1 is a 1950 photograph of the two inclined telescopes at Macquarie Island: the Hobart instruments are in the foreground of Fig. 4.

Previously, the University of Melbourne had established vertical GM telescopes at Macquarie Island and at Heard Island (53.0°S, 73.4°E, geomagnetic latitude 62°S) (together with ionization chambers modelled on the Carnegie Type-C chamber and an air-shower array at Macquarie Island) under the auspices of the Australian National Antarctic Research Expeditions (ANARE) program. The Uni-

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Fig. 1. A 1950 photograph of the two inclined telescopes at Macquarie Island, at geomagnetic latitude 64° south. K.B. Fenton (left) and N.R. Parsons are in the background. Note the shelf of Physical Reviews in the background – the nearest scientific library (and barber shop) were 1500 km away across stormy seas. The hut was tied down by steel cables to stop it being dislodged by the incessant winds and by the many 2500 kg elephant seals who disputed the occupancy of the cosmic ray scientists.

versity of Melbourne discontinued its cosmic ray research in 1950 and the ionization chambers and other instruments were transferred to the Tasmanian group. Cosmic ray observations ceased at Heard Island at that time, while the combined programmes continued at Macquarie Island.

Both islands were uninhabited and are situated in the "furious fifties", characterized by high winds, heavy seas, and extremely dangerous coasts with no safe harbours. All supplies were transferred to land in amphibious landing craft. The only communication to Australia was by radio using Morse code and radio-teleprinters. The research stations were typically staffed by 12–15 men who arrived each Austral summer in small (about 800 tonne) ships and, by necessity, stayed until the "relief" ship returned 12 months later. Cosmic ray studies were a high priority in the research programmes, there being two cosmic ray physicists at both islands for several years to maintain the relatively unreliable equipment of the time. The physicists were recruited several months prior to sailing south, and then trained in Melbourne and Hobart while assisting in assembling and packing all the technical material they would need "down south". By necessity the cosmic ray physicists were "jacks of all trades"; they assisted in the chores of running the stations; some were trained as nursing assistants to assist the one resident medical doctor in case surgery was necessary. Some had their appendix removed as a precaution – prior to that one expeditioner died as a result of a ruptured appendix. One cosmic ray physicist barely escaped death when the ice on a snow covered lake broke; his companion was drowned. The first cosmic ray physicists were all required to assemble their own cosmic ray huts from prefabricated components. It is on record that, for speed, the erection of the Macquarie Island hut was started simultaneously from both ends, and that the final components were 10 cm too long to close the final gaps in the walls [K.B. Fenton in Duldig (2000)].

The construction of a neutron monitor commenced at Hobart in early 1955. To increase its counting rate it was established at an altitude of 725 m on the slopes of Mt. Wellington, at whose foot Hobart is located. When first switched on in Hobart in April 1956 it used four "Nancy Wood Corporation" BF_3 counters. The monitor was enlarged to eight counters later that year and was further enlarged to 12 counters in April 1959.

In 1945, Dr. A.G. (Geoff) Fenton, the leader of the University of Tasmania group, initiated investigations into the properties of external cathode GM counters. By 1952 the group was able to mass-produce GM counters of up to 100 cm in length and 4 cm in diameter. These were years of very sparse funding and without the ability to manufacture these counters much of the subsequent IGY program would not have been possible. By 1955 the locally developed production techniques were producing counters with sufficient stability to study the 27-day variation and Forbush decreases, along with similar studies using the ionization chamber.

By 1955 ANARE had established its own cosmic ray research program co-located with Geoff Fenton's group at the University of Tasmania. In Hobart, at the time that planning for the IGY started in earnest, the Tasmanian group was already operating GM telescopes of cross-section 100×100 cm, an ionization chamber similar to those operated by Scott Forbush and was well on the way to having a neutron monitor in operation. As outlined below, data recording techniques were already well established, together with extensive data computation capabilities, and hourly data were being distributed world-wide. Two GM telescopes (one vertical; one measuring the East–West asymmetry) had just been installed at Mawson, the newly established Australian base on the Antarctic continent. This prior experience meant that the group had the facilities, experience and manpower to rapidly expand its observing program as detailed below. Observations of the giant Ground Level Enhancement (GLE) of 23 February 1956 by instruments at Mawson, Macquarie Island and Hobart soon added to that experience and posed questions that became central to much of the subsequent work in