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A Study of the Precipitation of Energetic Electrons from the Geomagnetic Field during Magnetic Storms[1]

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Abstract. The X rays produced by electron precipitation from the geomagnetic field have been further studied by means of scintillation counters carried on balloons launched simultaneously at four sites between Waterloo, Iowa, and Flin Flon, Manitoba, Canada. The latitude and detailed time profile were measured during two magnetic storms on September 25, 1961, and October 1, 1961. The integrated photons per centimeter^2 for the two storms show very different latitude profiles. On September 25 the intensity increased to the highest latitude (64.5° geomagnetic). On October 1 the profile was highest at 55° and dropped off to a very low value at the high latitude. These differences seem connected with the fact that the September storm was of the recurrent type, and the October 1 storm was more violent and was induced by a large solar flare. The detailed comparison with the total energy stored in the magnetic field, obtained from recent measurements of the trapped radiation in the energy range comparable with the balloon measurements, shows that about one or two orders of magnitude more energy was precipitated than is normally stored quiescently, indicating that during the magnetic disturbance the addition of energy to the electrons in the magnetic field is necessary. A more extreme case, observed on July 16, 1961, at Fort Churchill and at Minneapolis, shows that during a strong magnetic sudden impulse more than two orders of magnitude more energy was precipitated than is quiescently trapped. The precipitation has been observed with the data averaged in time intervals between 120 sec and 0.1 sec. We find that during periods of intense precipitation a large fraction of the precipitation occurs in bursts of high intensity lasting only 0.1 sec. It is suggested that these rapid bursts can account for the flashes or pulsations observed in strong auroral storms. Power spectrum analysis methods have been applied to the counting rate data, and we find periodic precipitation occurring with periods of 0.8, 1.6, and 3.2 sec and higher multiples. It is suggested that this constitutes direct evidence for particle bunches near 60-kev energy oscillating between conjugate points in the geomagnetic field. A Chree analysis applied with the large impulsive bursts as zero epoch confirms this picture and shows that the same periods occur in fixed phase relationship to the bursts.

1. INTRODUCTION

Since 1957, when energetic X rays associated with magnetic storms were first detected at balloon altitudes, the authors, as well as investigators in several other groups, have reported extensive observations on them. Attempts have been made to systematize the data from these measurements in the hope that the balloon data could yield valuable information about energetic processes taking place in the magnetic field of the earth. Such attempts to correlate the results have been difficult because of the sporadic nature of the data, both in geomagnetic position and in time. We have therefore conducted a more systematic series of measurements, more suitable for interpretation in useful terms, and this will constitute the principal part of this paper.

One purpose of the experiments was to investigate an effect we have called 'dumping.' The word has acquired the meaning that electrons normally trapped in the geomagnetic field as part of the Van Allen radiation are precipitated out of the trapping region as the result of various kinds of disturbances. Recent data of

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