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A NEW VIEW OF THE RING CURRENT

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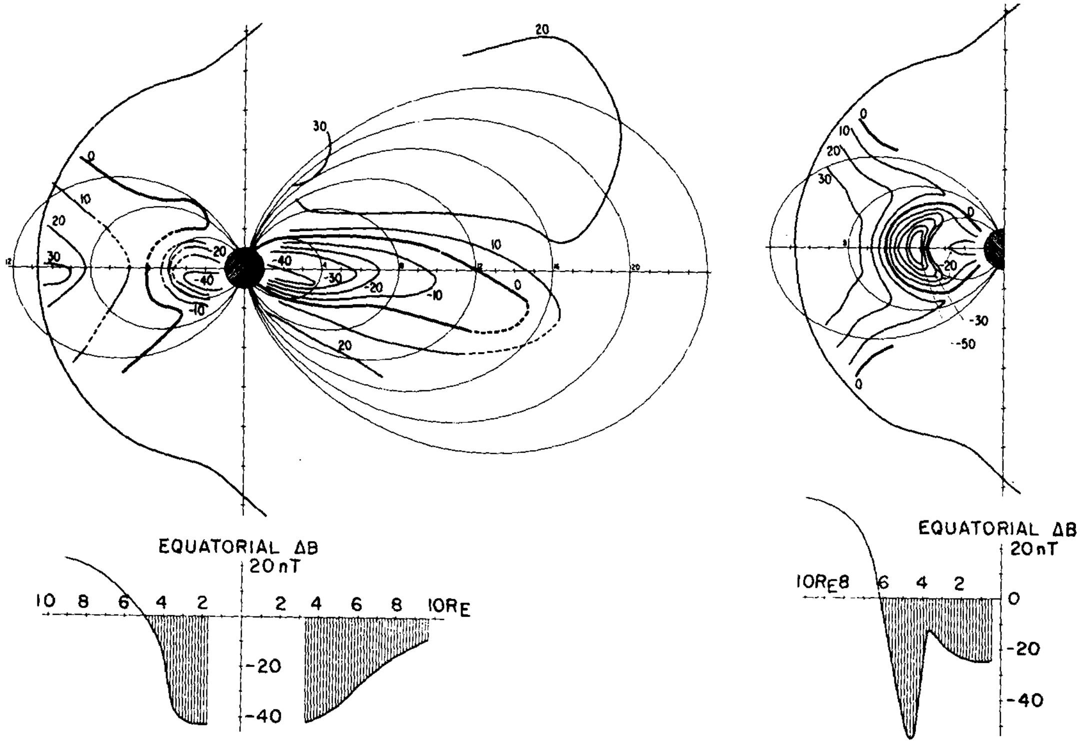
The concept of the ring current was originally introduced about 40 yr ago to explain the worldwide field decrease observed during magnetic storms. Evidence for such a ring current has been found by satellite observations of particles and magnetic field. The idea that a ring current exists even at quiettimes has developed in recent years because it takes many days for a stormtime ring current to decay and because protons having energies similar to those of the particles considered to be responsible for the stormtime ring current are observed even during quiet periods.

OGO 3 and 5 observations have provided the first reliable magnetic field survey in the inner magnetosphere. The observations showed that both the intensity and distribution of the quiettime ring current are very much different from what has been usually thought. Figure 1(*a*) shows a contour map in the noon-midnight meridian plane of average ΔB observed during quiet periods by the Rb magnetometers on OGO's 3 and 5, where ΔB is defined as the observed scalar field minus the magnitude of a reference field calculated from a spherical harmonic expansion of the main field. The existence of a negative ΔB region near the dipole equator is clearly indicated. The minimum ΔB under average quiet conditions is about -40 nT (-40 γ). An example of a ΔB contour map for a theoretical ring current model is shown in Figure 1(*b*) (From Ref. 1). Important differences between the two ΔB distributions can be seen, for example, in the variations of ΔB on the dipole equator as a function of radial distance, as shown below the contour maps. The observed ΔB continues to decrease with decreasing distance; whereas ΔB in the theoretical model has a minimum at the center of a toroidal belt and recovers substantially toward the Earth. This indicates that the distribution of particles responsible for the equatorial $-\Delta B$ is different from that assumed in the model.

The problem of the quiettime ring current was once regarded as being settled when a belt of low-energy protons was observed by Frank (Ref. 2) and was identified as the quiettime ring current belt of the type shown in the model. That this was a case of misidentification becomes clear in Figure 2, where examples of OGO 3 and 5 observations along individual orbits are presented. Figure 2(*a*) shows the ΔB observed on OGO 3 and the plasma parameter β determined from Frank's observations of protons and electrons made on the same satellite, where β is the ratio of the plasma energy density to the



(*a*) Observed by OGO's 3 and 5, noon-midnight sectors, Kp = o to 1.

(*b*) Hoffman-Bracken (Ref. 1) quiettime ring current model.

Figure 1–Equal ΔB contours.

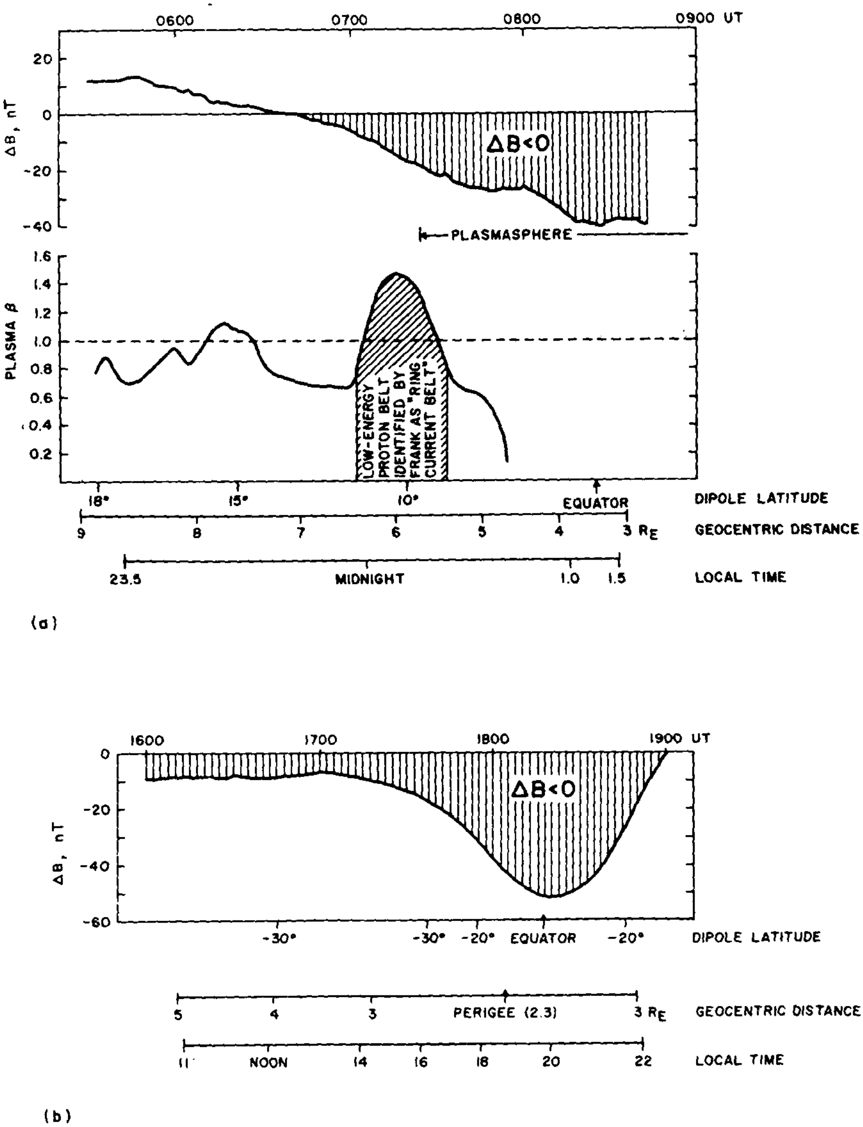


Figure 2–Satellite ΔB observations along individual orbits. (*a*) ΔB near midnight equator observed by OGO 3 Rb magnetometer. (*b*) ΔB near perigee observed by OGO 5 Rb magnetometer.

magnetic field energy density. The graph covers geocentric distances approximately from $9R_E$ to $3R_E$ (Earth radii) near midnight and from geomagnetic latitude 18° to a little below the dipole equator. It is clear that the high β belt near $6R_E$, which was called the "terrestrial ring current," cannot be responsible for the $-\Delta B$ observed well inside the plasmasphere. Figure 2(*b*) shows an example of the ΔB distribution obtained during a relatively quiet period (of $Kp = 1+$) by OGO 5 near perigee at $2.3\ R_E$; ΔB is about -50 nT (-50) near the dipole equator, which was crossed shortly after perigee.

Figure 3 summarizes the differences between the old view of the quiettime ring current (Fig. 3(*a*)) and the new view based on the OGO observations (Fig. 3(*b*)). In the old model a toroidal proton belt of doughnut shape was considered the cause of the field decrease in the near-Earth region. The OGO observations imply that the plasma responsible for this field decrease resides in an equatorial disklike region inside the plasmasphere.

The field energy density associated with the minimum ΔB (of about -40 nT) is greater than the plasma energy density estimated from the available thermal plasma observations by a factor of 10 or more. On the other hand, Frank claims that there are no significant fluxes of protons in the energy range 0.08 to 8.0 fJ (0.5 to 50 kEV) in the region in question. Thus, the identification of particles constituting the quiettime ring current is still left for future investigation.

REFERENCES

1. Hoffan, R. A.; and Bracken, P.A.: Magnetic Effects of the Quiet-Time Proton Belt. J. Geophys. Res., Vol. 70, 1965, p. 3541-3556.

2. Frank, L. A.: Relationship of Plasma Sheet Ring Current, Trapping Boundary, and Plasmapause Near the Magnetic Equator and Local Midnight. J. Geophys. Res., Vol. 76, 1971, p. 2265-2275.

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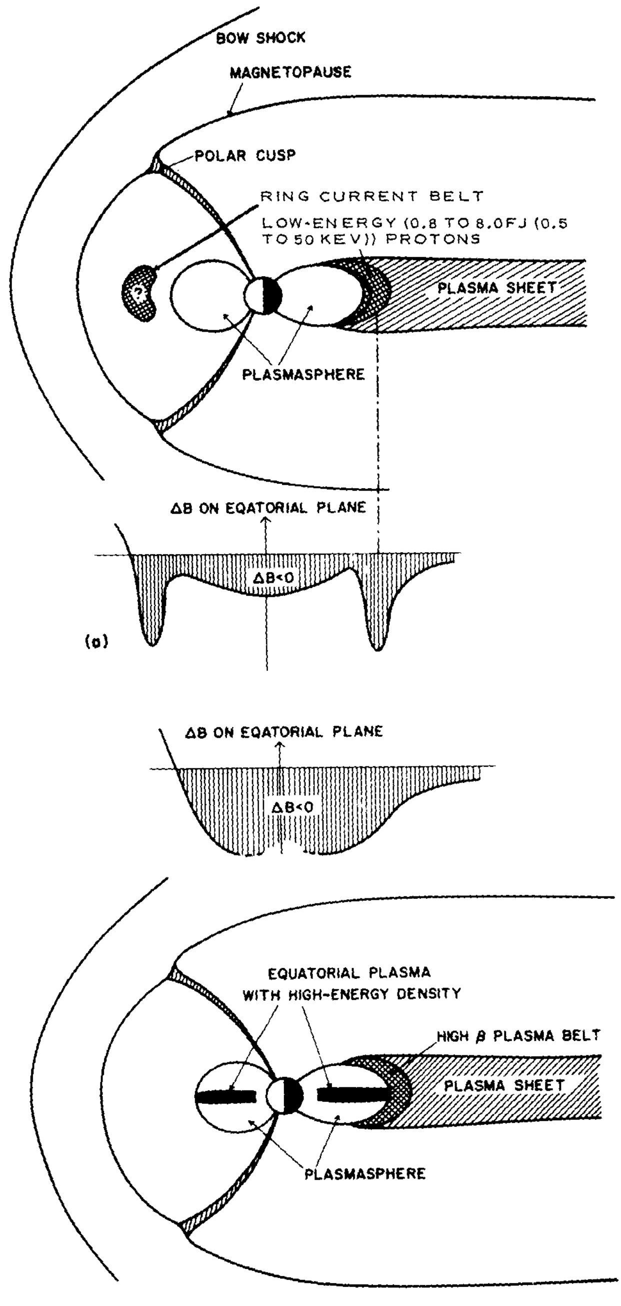

Figure 3–Quiettime ring current. (*a*) Conventional view based on old models. (*b*) New view based on OGO observations.