Space Physics: Ionosphere (50 points)

1. In the collisionless ionosphere, using ionosonde for sweeping frequencies in vertical incidence mode: (a) calculate the reflection frequency of O-wave where the electron density is 10^6 el/cm^3 (10 points) and (b) show the reflection frequency of X- wave is larger than those of O-wave and Z-wave (10 points).

2. Given the critical frequency of F2 region to be 10 MHz, with what conditions can one receive the echoes from the F2 region by transmitting the ionosonde with 20 MHz? (10 points)

3. Define and describe the features of D, E, F1 and F2 layers of the ionosphere. (20 points)

Space Physics: Magnetosphere (50 points)

4. Please explain
(a) three adiabatic invariants. (9 points)
(b) physical meaning of Ohm's law in ideal MHD equations. (8 points)
(c) the frozen-in condition. (9 points)

5. (a) Derive the diamagnetic current from the equilibrium state of MHD momentum equation. (6 points)
(b) Discuss the direction of cross-tail current based on the particle and fluid points of view. (6 points)

6. Under the assumption of steady state in one dimension,
(a) explain the possible shock/discontinuity structures of Earth's magnetopause in the northward and southward IMF Bz conditions, respectively. (6 points)
(b) determine the shock speed if a spacecraft detects a shock with the density jump from 2 cm^{-3} to 7 cm^{-3} and solar wind speed change from 400 km/s to 600 km/s. (6 points)

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