Simple rocket-borne spectrometer to measure the ion composition of the mesosphere

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Preciously flown rocket-borne ion mass spectrometers required cryogenic pumping. There have not been flights since 1993 because of technical difficulties and expenses related to the frequent refilling of liquid helium or neon. Advances in (1) aerodynamic modeling, (2) mass spectrometer design, and (3) ion detection technology make possible a new approach to mass spectrometry in the mesosphere. The pumping is provided by the shock wave around the rocket. Direct Simulation Monte-Carlo method has been applied to simulating the air flow around the rocket payload. We find that if the forward deck of the payload is supported on a stalk of smaller diameter (10 cm for example), that a low-density void is created below the forward deck by the flow around the payload, assuming that the payload is pointed in the ram direction. The air density below the deck is reduced from ambient by a factor 7 and 15 at altitudes of 80 and 90 km, respectively. The mass spectrometer is exhausted into this void which acts as a pump. In a conservative scenario, the spectrometer is kept evacuated on the upleg then opened at the apogee both at the inlet and exit. Data are acquired on the downleg to 70 km, below which the pressure in the low-density void becomes too high. Second, we use the rotating field mass spectrometer which operates at higher pressure (up to 30 mTorr) than the quadrupole spectrometer because the ion path length is shorter (2 cm) and because a larger ion acceleration potential is used that reduces the ion-neutral collision cross section. Third, we use a new design of channel electron multiplier that has been shown to operate at pressures up to 10 mTorr in the lab, corresponding to the number density at approximately 80 km in the arctic winter.