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EFFECTS OF NEUTRAL GAS RELEASE ON CURRENT COLLECTION DURING THE CHARGE-2 ROCKET EXPERIMENT

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Abstract. Observations of current collection enhancements due to cold nitrogen gas control jet emissions from a highly charged rocket payload in the ionosphere are reported. These observations were made during the second cooperative high altitude rocket gun experiment (CHARGE-2) which was an electrically tethered mother/daughter payload system. Gilchrist et. al (1989), provides a detailed summary of the observations. The current collection enhancement was observed at the daughter payload located 100 to 400 m away from the mother which was firing an energetic electron beam . We interpret these results in terms of an electrical discharge forming in close proximity to the daughter during the short periods of gas emission. The results indicate that it is possible to enhance the electron current collection capability of positively charged vehicles by means of deliberate neutral gas releases into an otherwise undisturbed space plasma. These results can also be compared with recent laboratory observations of hollow cathode plasma contactors operating in the "ignited" mode.

Experimental observations of current collection enhancements due to cold nitrogen gas control jet emissions from a highly charged, isolated daughter payload in the nighttime ionosphere have been made. These observations were derived from the second cooperative high altitude rocket gun experiment (CHARGE-2) which was an electrically tethered mother-daughter payload system. The rocket flew from White Sands Missile Range (WSMR) in December, 1985. The rocket achieved an altitude of 261 km and carried a 1 keV electron beam emitting up to 48 mA of current (Myers, et al., 1989a). The mother payload, carried the electron beam source, while the daughter acted as a remote current collection and observation platform and reached a distance of 426 m away from the main payload. Gas emissions at the daughter were due to periodic thruster jet firings to maintain separation velocity between the two payloads.

The effect of the gas enhanced current collection can best be shown by comparison with collection results without gas emissions. This is shown in Figure 1 where the altitude dependence of the normalized tether current (equal to current collected at the daughter payload) is plotted. The normalization factor is beam current which, in steady state, is assumed to be equal to the total return current to the two payloads. Both the case of gas and no-gas emissions are shown. As can be seen substantial enhancement to the no-gas current collection at the daughter are indicated. Near apogee, enhanced collection levels approach unity.

For the no-gas case, with identical collection processes at the two payloads, the normalized tether current would be 0.29 which is equal to the ratio of daughter to daughter plus mother current collection areas. This condition is only achieved near apogee. Therefore, other preferential processes near the main payload must be operative at lower altitudes (Myers, et al., 1989b).

Without the gas emission, substantial vehicle charging was observed for beam emissions exceeding thermal collection current limits (≈ 3-5 mA) of the payload system. In those cases, the mother payload achieved charging levels of 400 to 600 V, or approximately 50% of beam energy. Because of the low resistance electrical connection to the daughter payload, it also charged to near the same potential. During the collection enhancement, charging was observed to drop below 10% of beam energy. On one occasion, when a 450 V power supply was connected in series between the two payloads through the tether (raising the daughter potential relative to the mother), the mother potential was actually observed to be driven negative during electron beam emission.

The enhancement is interpreted here in terms of an electrical discharge forming in close proximity to the daughter vehicle during the short periods of gas emission. The discharge resulted from accelerated ionospheric electrons, attracted to the charged payload, ionizing a fraction of the neutral gas plume around the daughter payload. This description is similar to models describing recent laboratory observations of hollow cathode plasma contactors operating in the "ignited" mode (Davis, et al., 1989; Williams, et al., 1987). The explanation for the altitude dependence indicated in Figure 1, is in part due to the same preferential processes near mother payload indicated for the no-gas case. Also, it is likely that the discharge around the daughter payload is dependent on the background electron density.

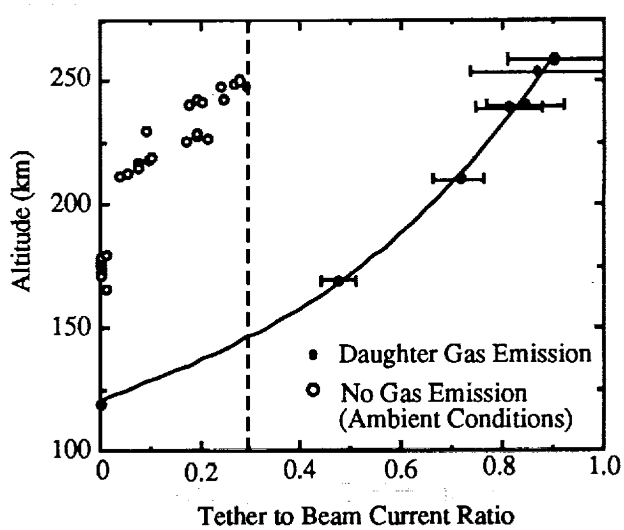

Figure 1 - Plot of tether to beam current ratio versus altitude with and without daughter gas emissions. The ratio of daughter to total (daughter plus mother) current collection areas, 0.29, is identified by the dashed line.

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