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Long-term trends in lunar exposure to the Earth's plasmasheet

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The Moon passes through the tail of the Earth's magnetosphere once every lunation. The crossing takes four or five days, during which time the Moon will encounter the plasmasheet whenever the motion of the two objects brings them to the same region. During these encounters the lunar surface may be exposed to hot dense plasma and accumulate electrical charge from that plasma. To assess the likely level of surface charging during any lunation we seek to estimate the period for which the Moon will be exposed to the plasmasheet during each lunation. We estimate this exposure using a plasmasheet model based on the neutral sheet model of Tsyganenko et al (1998). We have applied this model to study both (a) the long-term effects arising from the natural periodic motions of the Moon and plasmasheet and (b) the short-term effects arising from the modulation of neutral sheet location by the interplanetary medium. The results indicate that the exposure is strongly modulated over an 18.6 year cycle defined by precession of the Moon's orbit. This precession controls the ecliptic latitude at which the Moon crosses the magnetotail and thus modulates its exposure to the plasmasheet. When the Moon has maximum north latitude in June (e.g. 1979, 1997, 2015) the latitudinal motions of plasmasheet and Moon are in phase and the model predicts a relatively high exposure to the plasmasheet (38-40 hours per lunation). In contrast when the Moon has maximum south latitude in June (e.g. 1970, 1988, 2006, 2025) the latitudinal motions of plasmasheet and Moon are in anti-phase and the model predicts a low exposure (12-15 hours per lunation). This long-term modulation of plasmasheet exposure is an important factor to consider in assessing environmental hazards for lunar exploration such as charging and dust transport. In particular, one must take great care when using environmental measurements made during periods of low exposure.