Destruction regimes of Sun-skimming and Sun-plunging comets

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We establish and model destruction regimes for *close sun-grazers*, i.e. comets of small enough perihelia ($q \leq$ a few $R_\odot$) and large enough mass ($M_o \geq 10^{13}$ g) to reach the inner solar corona or below. These can be divided into *sun-skimming* and *sun-plunging* according to whether their M_o, q values confine them to atmospheric densities $n \leq 10^{14}\text{cm}^{-3}$ where mass loss is dominated by insolative sublimation, or let them reach $n \geq 10^{14}\text{cm}^{-3}$ where hydrodynamic interactions with the dense chromosphere take over (bow-shock-heated ablative mass loss, ram pressure pancaking and deceleration).

Being rare, no sun-plungers have yet been detected but they are of potentially great interest. Recent years have seen the first direct monitoring of three sun-skimmers in the low corona by SDO at EUV wavelengths. Both sun-plungers and sun-skimmers offer novel diagnostics of both cometary and solar conditions.

We show that, due to their much higher speeds than planetary impacts, sun-plungers are likely dominated by pancaking and ablative mass-loss, rather than deceleration, even for quite inefficient bow-shock heat transfer, but we obtain solutions for ablation- and deceleration-dominated, and for intermediate, cases. All involve rapid local deposition of nucleus kinetic energy and momentum within a few 100 km near the photosphere. This occurs at atmospheric density $n_{peak}(\text{cm}^{-3}) \approx 3 \times 10^{16}(X\mu_{-2}^3 M_{15})^{1/2}$ for incident mass $M_o = 10^{15} M_{15}$ g, incident angle $\theta = \cos^{-1}(10^{-2}\mu_{-2})$ to the vertical, and parameter X ranges from 0.001 up to 1. Break-up into Y fragments reduces n_{peak} by a factor $\approx Y^{-1/3}$. This deposition will drive hot rising 'airburst' plumes and internal helioseismic waves similar to magnetic flare effects. In the normal ablation-dominated case (small X) the hot airburst will exhibit essentially cometary abundances (metallicity $\gg$ solar).

Though sun-skimmer nuclei are vaporized by 5800 K ($\approx$ 0.6 eV/photon) photospheric sunlight, their dissociation, ionization and heating up to EUV temperatures (10–100 eV) have to involve chromospheric EUV (10 eV/photon), 2 MK coronal thermal conduction (200 eV/electron) and conversion of nucleus kinetic energy (2 keV/nucleon). Coronal heat flux may be important in small sun-skimmers with tenuous comae and tails but kinetic energy conversion must dominate in large ones like Lovejoy 2011.

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