The Nucleus of Comet 67P/Churyumov-Gerasimenko - Nucleus Mass, Mass Loss, Porosity and Implications

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The radio science experiment RSI on board Rosetta determined the mass of the nucleus of comet 67P/Churyumov-Gerasimenko at the start of the prime mission from August to November 2014 (GM = 666.2±0.2 m^3/s^2) and shortly before the end of the mission from July to September 2016 (GM = 665.5±0.1 m^3/s^2). The mass loss is ΔM = 10.5 ± 3.4·10^9 kg, about 0.1% of the nucleus mass. Almost 50% of the mass loss occurred during the 32 days before and 62 days after perihelion. The nucleus mass combined with the new very precise nucleus volume of 18.56±0.02 km^3 yield a bulk density of 537.8±0.7 kg/m^3. This low bulk density suggests that the nucleus is highly porous. The porosity is constrained by the observed bulk density, the density of amorphous water ice and the density of compacted nucleus dust material. For a range of compacted dust material density from 2200 to 3100 kg/m^3, the porosity varies between 67% - 78% when the dust-to-ice mass ratio $F_{nucleus}$ for the nucleus body lies in the range $3 < F_{nucleus} < 7$. The nucleus is thus a highly porous very dusty body with very little ice. The total mass loss puts hard constraints on the models of interpretation of the observations from other instruments on Rosetta. The newly calculated mass loss from gas, based on ROSINA observations, suggests that F_{space}, the dust-to-ice mass ratio of cometary matter in space beyond the Hill sphere of the nucleus is of the order of F_{space} ~ 0.5 and therefore at least six times, and perhaps as much as 14 times, smaller than $F_{nucleus}$.