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Characterization of the physical properties of the ROSETTA target comet 67/Churyumov-Gerasimenko at large heliocentric distance

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Abstract

ESA's Rosetta spacecraft will rendezvous with the Jupiter family comet (JFC) 67P/Churyumov-Gerasimenko (67P/C-G) in 2014. The results we present here are based on the analysis and interpretation of photometric and spectroscopic ground based observations of 67P/C-G at large heliocentric distance. The aim of this study is to provide a good characterization of the nucleus of the comet and its dust environment far from the Sun. This information is essential for a good planning of the rendezvous of the ROSETTA spacecraft with 67P/C-G, which will take place at r ≈ 4.5 AU. Moreover, this study provides valuable information on the basic physical properties of the nucleus of JFCs and their dust environment far away from the Sun. It also helps in clarifying if the behaviour of 67P/C-G is typical of a JFC or not.
The observations were carried out with the ESO Very Large Telescope between April 2004 and July 2007, when 67P/C-G was at r ≥ 4.6 AU. The comet appears point-like at all observing epochs, indicating that no significant coma is present around the nucleus. From 67P/C-G images taken in May and August 2006 we determined a rotational period of the nucleus of 12.7047 +/- 0.0011 h and a linear phase function coefficient beta = 0.076 +/- 0.003 mag/deg, higher than the usual one adopted for cometary nuclei [1]. Thanks to the July 2007 dataset we determined that 67P/C-G does not show opposition effect at small phase angles (0.5° - 10°). We estimated the large-to-small axis ratio a/b > 1.45 +/- 0.09 and an effective nucleus radius of 2.38 +/- 0.04 km, assuming an albedo of 0.04.
Based on broadband colour indices and reflectance spectra, the nucleus of 67P/C-G is slightly redder than the Sun, with a constant reddening slope of about 11%/1000 Å and it does not show colour variation with rotational phase. The reflectance spectra of the nucleus of 67P/C-G do no show any absorption or emission features.
In April 2004, June 2004 and May 2006 we detected a tail-like structure of heavy grains associate with 67P/C-G. It displays a mean R filter surface brightness of 27.5 ± 0.1 mag/"^{2} in April 2004, 28.1 ± 0.1 mag/"^{2} in June 2004 and 28.5 ± 0.2 mag/"^{2} in May 2006. Using the June 2004 observations, for the first time we determined also the visible colours of the tail-like structure: V-R = 0.95 ± 0.14 mag/"^{2} and R-I = 0.39 ± 0.14 mag/"^{2}, which correspond to a mean spectral reddening of about 17 %/1000 Å. Thus, on the average, the tail-like structure looks redder than the nucleus of 67P/C-G. Based on geometrical considerations (position angle of the tail-like structure), we concluded that the tail-like structure is more compatible with a neck-line activity of the comet during the recent perihelion passage (i.e. 2002/03) rather with an old dust trail, composed of large dust particles emitted during the previous orbits of 67P/C-G, i.e. 1995/96 and earlier. Our conclusion is strengthened by the fact that the surface brightness of the tail-like structure is not a linear function of log(r), as it would have been expected for an old dust trail. Since the comet's activity around perihelion has shown similar behaviour during the last three orbital passages, it is fair to assume that the comet's behaviour at large heliocentric distance has not changed from one orbital revolution to the other, leading us to expect that during its approach to 67P/C-G, ROSETTA will find the same conditions detected during our observations.

Bibliography

[1] Tubiana et al. (2008) *A&A*, 490, 377-386.