NEOROCKS: COMPOSITIONAL PROPERTIES OF NEAR-EARTH OBJECTS FROM SKY SURVEYS

A. V. Sergeyev [1] B. Carry [1] and the NEOROCKS team [2]

[1]Observatoire de la Côte d'Azur, CNRS, Laboratoire Lagrange, France
[2]M. Marsset, P. Pravec, D. Perna, F. E. DeMeo, V. Petropoulou, M. Lazzarin, F. La Forgia, I. Di Petro, E. Dotto, M. Banaszkiewicz, S. Banchi, M.A. Barucci, F. Bernardi, M. Birlan, A. Cellino, J. De Leon, M. Lazzarin, E. Mazzotta Epifani, A. Mediavilla, J. Nomen Torres, E. Perozzi, C. Snodgrass, C. Teodorescu, S. Anghel, A. Bertolucci, F. Calderini, F. Colas, A. Del Vigna, A. Dell'Oro, A. Di Cecco, L. Dimare, P. Fatka, S. Fornasier, E. Frattin, P. Frosini, M. Fulchignoni, R. Gabryszewski, M. Giardino, A. Giunta, T. Hromakina, J. Huntingford, S. Ieva, J.P. Kotlarz, M. Popescu, J. Licandro, H. Medeiros, F. Merlin, F. Pinna, G. Polenta, A. Rozek, P. Scheirich, A. Sonka, G.B. Valsecchi, P. Wajer, A. Zinzi.

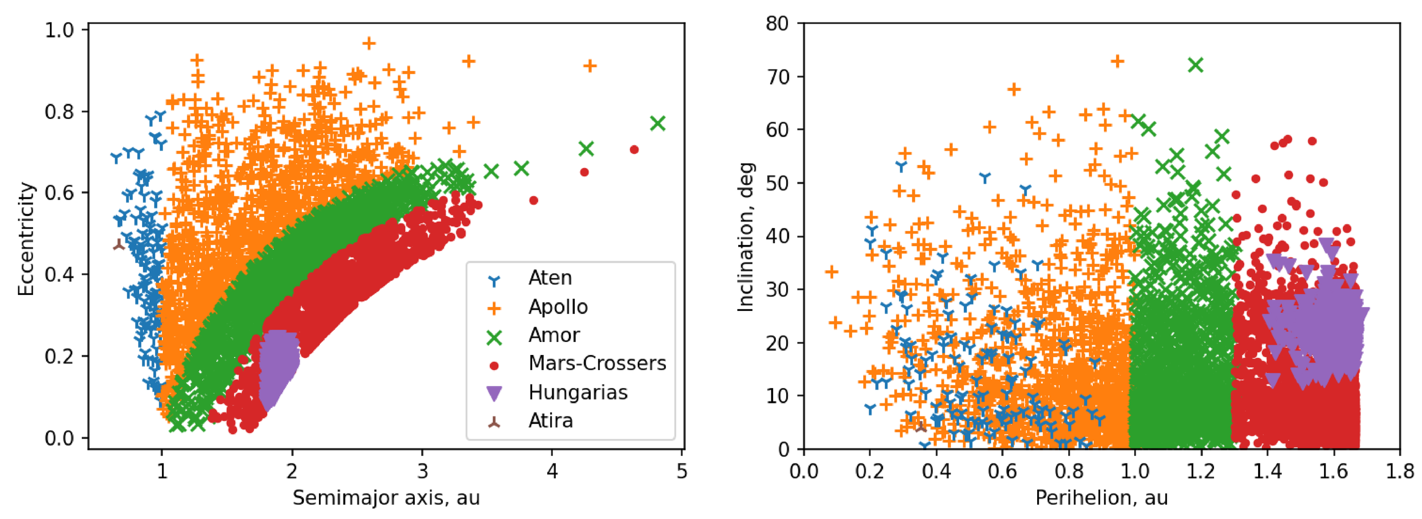
The NEOROCKS project focuses on the study of characterizing the population of near-Earth objects by thoroughly examining their properties. This comprehensive study aims to improve our understanding of these celestial bodies, their origins, and the potential risks they may pose to Earth. By investigating the diverse properties of NEOs, NEOROCKS contributes valuable insights to the broader scientific community and helps prepare future space missions and planetary defense strategies.
In order to promote the study of NEO properties, the NEOROCKS project has prepared an extensive database of asteroid color indices. This database is compiled by combining multi-wavelength observations, allowing us to analyze the compositional properties and surface characteristics of these celestial bodies. Through the analysis of this color index database, we identified trends, correlations, and potential links between asteroid properties, gaining a deeper understanding of their origins and the processes shaping their surfaces.

Near-Earth Object (NEOs) Dataset collectiing

We collected and compared Near-Earth Object (NEO) color data from four recently published sources:

1. Sloan Digital Sky Survey (SDSS) (Sergeyev and Carry, 2020)
2. SkyMapper Southern Survey (SMSS) (Sergeyev et al., 2021)
3. Gaia DR3 visible spectra (Galluccio et al., 2022)
4. Ground-based spectra (Mahlke et al., 2022)

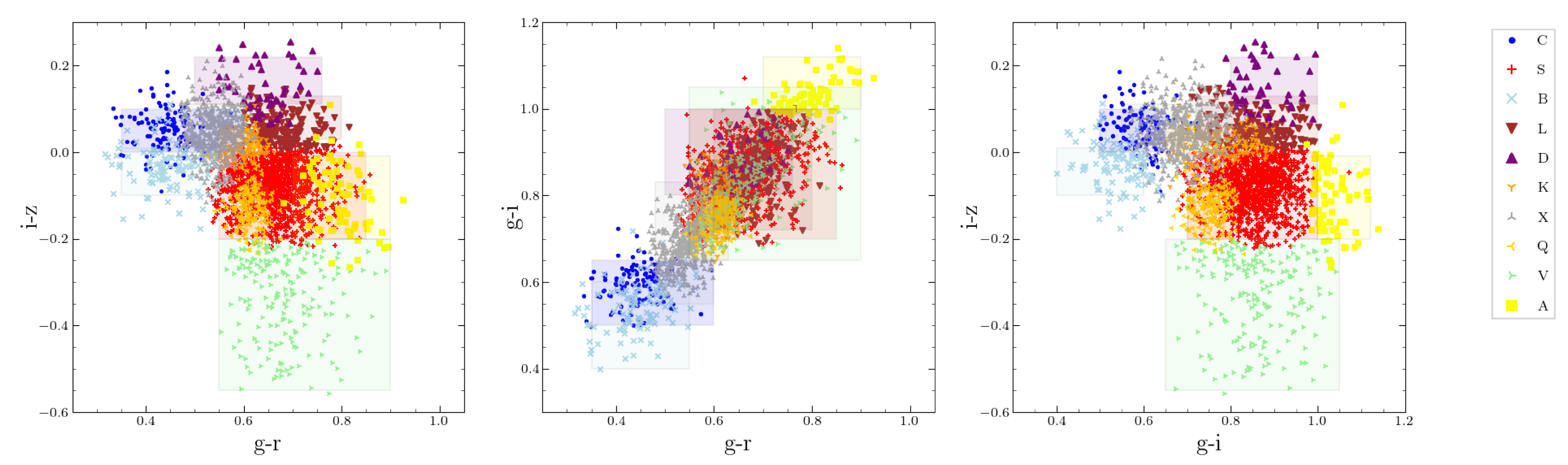
We converted an asteroid reflectance from spectra surveys to a set of colors in the SDSS photometric system to aim to create a large, homogeneous dataset. In such a way we gathered the colors of 7,401 individual NEOs including 2,277 Near-Earth and 5,124 Mars-Crosser asteroids.



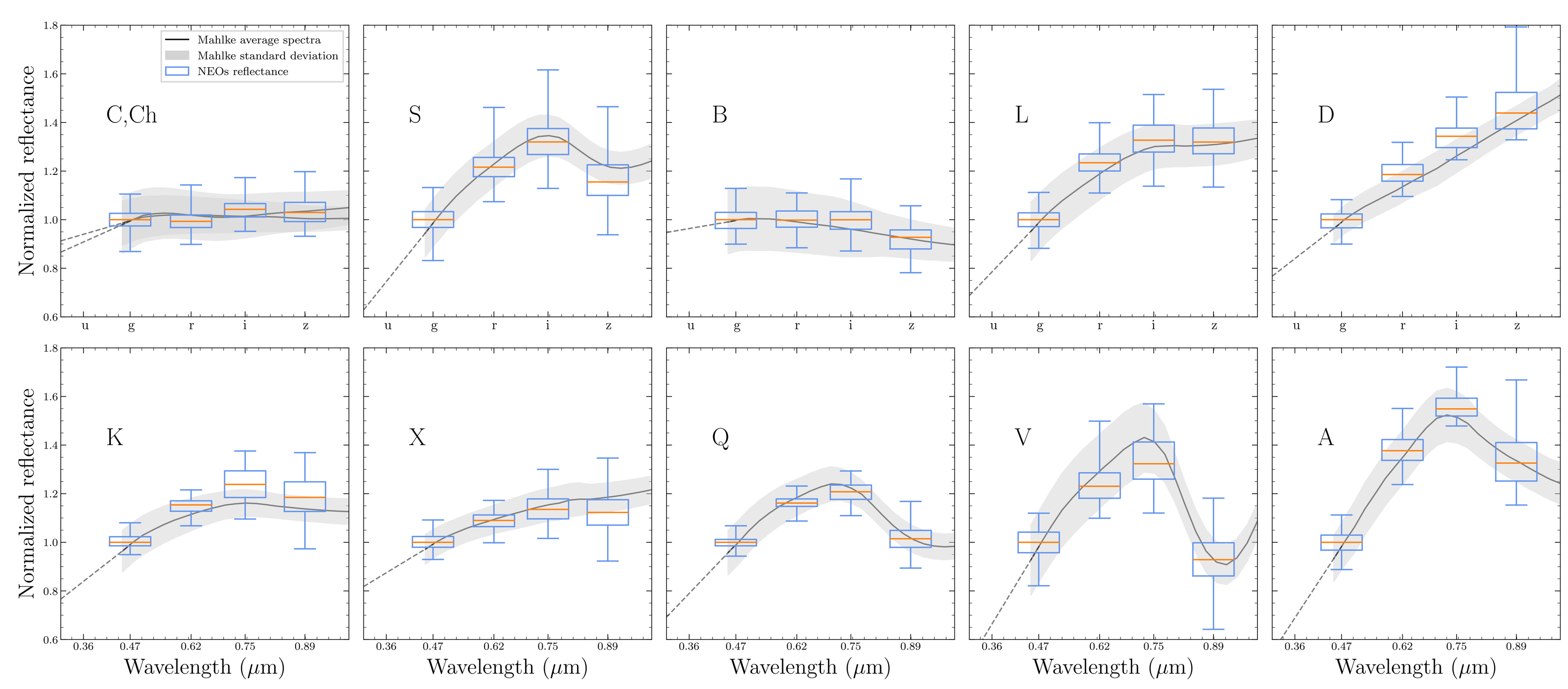
Distribution of the orbital elements of the NEO NEOROCKS asteroids, color-coded by dynamic class.

Multicolor taxonomy

We employed a method adapted for multi-color photometry, based on M. Mahlke's recent taxonomy update, which builds upon the popular Bus-DeMeo classification system. To determine the likelihood of each asteroid belonging to one of ten extensive taxonomic groups, we utilized a probabilistic technique that factored in the uncertainties in asteroid measurements.

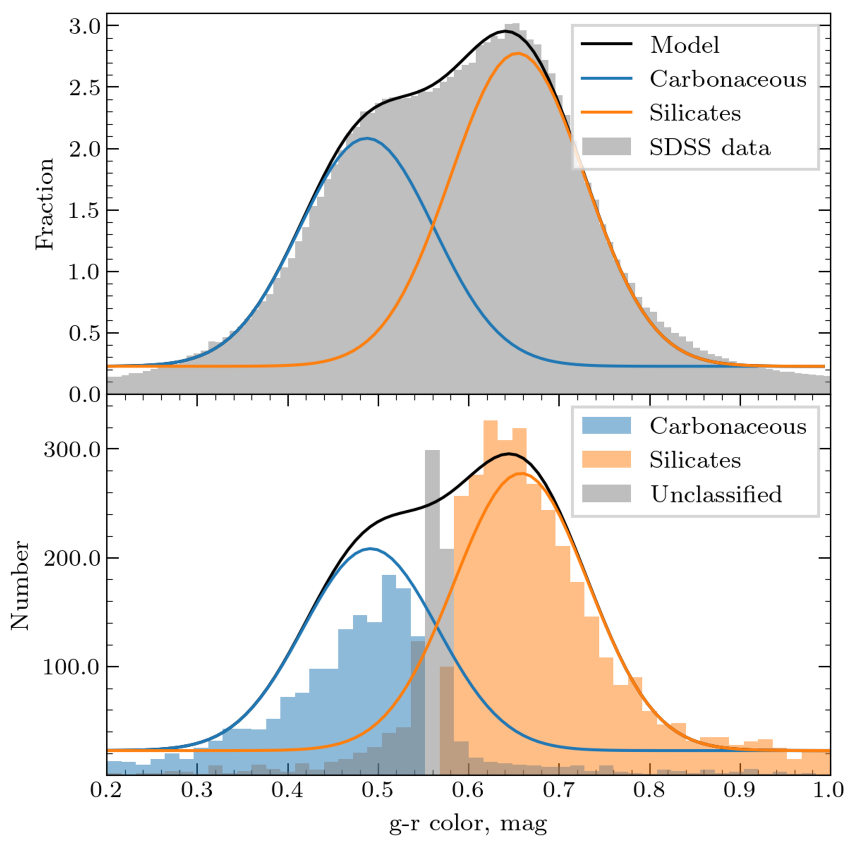


The taxonomic distribution of NEOROCKS near-Earth objects (NEOs) was calculated using precise color boundaries for taxonomy within the three-dimensional color indices of the Sloan Digital Sky Survey (SDSS) space. Color boundaries for taxonomy were determined by transforming spectral templates from the Mahlke/Bus-Demeo classification system.



Asteroids' pseudo-reflectance spectra were derived from their g-r, g-i, and i-z colors. The distribution of values for each band is shown with whiskers, representing the 95% extrema and the 25%, 50%, and 75% quartiles. Additionally, the corresponding template spectra from the taxonomy are depicted for each class.

One color taxonomy

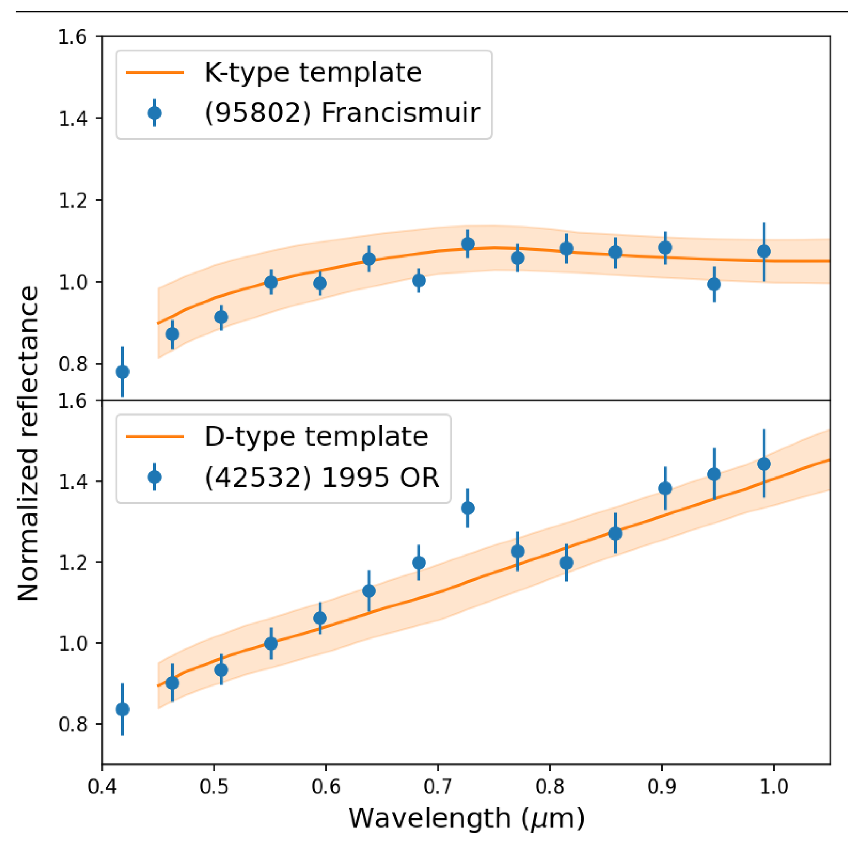


Left-top: The color distribution of one million asteroids from the SDSSdataset was approximated using a combination of two Gaussian distributions (illustrated by the black line). The model represents the two primary taxonomic asteroid classes, Silicate (shown in orange) and Carbonaceous (shown in blue).
Left-bottom: The distribution of g-r colors and taxonomy of NEOROCKS NEOs classified using the two-component Gaussian model mentioned above. The Carbonaceous and Silicate taxonomic complexes are depicted in blue and orange, respectively. Unclassified asteroids, where the probability of belonging to either complex is similar, are marked in gray.

Right: The confusion matrix presents a comparison between single-color (g-r) taxonomy predictions and three-color (g-r, g-i, i-z) taxonomy results, displaying the proportions of true positives, false positives, true negatives, and false negatives.

	C	B	X	K	L	S	V	Q	D	A
C_1	0.98	0.95	0.54	0.06	0.00	0.02	0.02	0.01	0.03	0.00
S_1	0.01	0.01	0.13	0.76	0.99	0.91	0.91	0.93	0.79	1.00
U	0.01	0.04	0.33	0.18	0.01	0.07	0.07	0.06	0.18	0.00

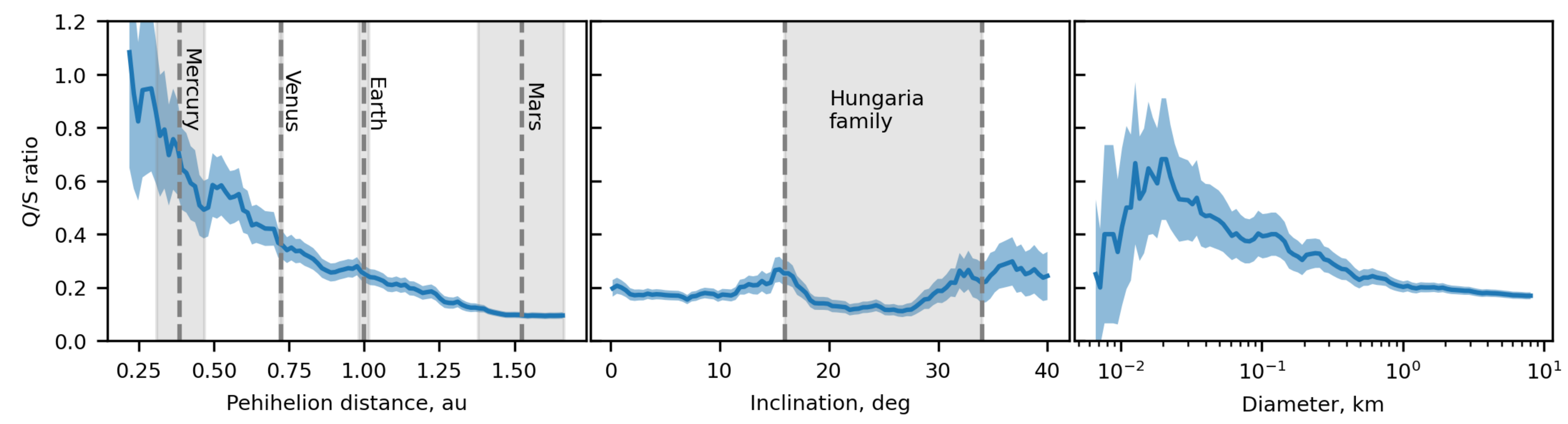
Space mission targets



The NEOROCKS NEOs data was utilized to examine the composition of prospective candidates for future space missions, including around one hundred potential candidates for the ESA Hera mission. In this context, we showcase the Gaia spectra for two of these candidates (95802) Francismuir and (42532) 1995 OR, selected from a narrowed-down list of seven remaining contenders being considered for a flyby by the Hera mission. The orange line shows reflectance templates of P-type asteroids (top) and D-type asteroids (bottom).

Space weathering

We present here the results of analysis on space weathering using the NEOs NEOROCKS catalog, which includes 1,175 weathered S-type and 196 fresh Q-type silicate asteroids. In order to analyze the factors contributing to the rejuvenation of asteroid surface features, we calculated the Q-type to S-type ratio in relation to various asteroid dynamical and orbital properties.



Our computations clearly demonstrate a rise in the fraction of fresh asteroids as the perihelion distance decreases. The proportion of Q-type asteroids increases from approximately 0.2 to 1 over a distance range of 1.6 to 0.2 astronomical units (left). The Q/S ratio increases as the asteroid diameters decrease but falls for the smallest NEOs, which could be due to the prevalence of monoliths where resurfacing is challenging (right). We did not find a correlation between space weathering and minimum orbit insertion distance (MOID) as well as the inclination of asteroid orbits (middle).

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alexey.v.sergeyev@gmail.com