SPIN AND SHAPE MODELS OF 16 NEAs OBSERVED WITHIN THE NEOROCKS PROJECT

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NEOROCKS (NEO Rapid Observation, Characterization and Key Simulations) project is a European Union's Horizon 2020 research and innovation programme. One of its several goals is a physical characterization of near-Earth asteroids through photometric observations performed by large and small ground-based telescopes.

Photometric observations were carried out from February 2020 to February 2023. We chose observable near-Earth asteroids with at least some existing data available and preferably no spin-pole/shape solutions. We used the Danish 1.54-m telescope located at La Silla (Chile) and Mayer 0.65-m telescope in Ondřejov (Czechia).

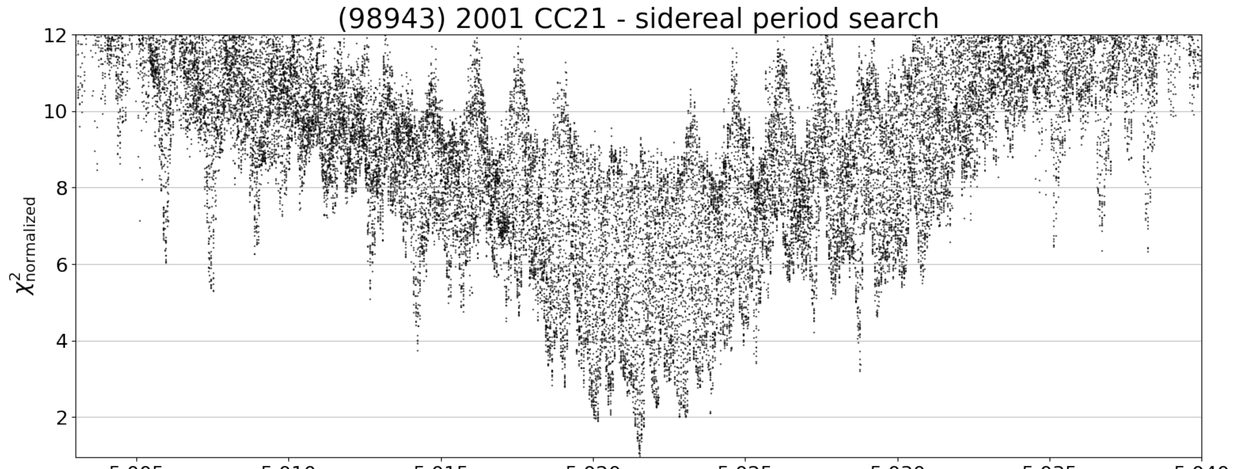
Asteroids' **spin-pole direction and shape** determination requires photometric data of the asteroid from various aspects. Dense data from not-too-distant apparitions are preferred. We employed the light-curve inversion method [1, 2] used in the C package written by Josef Ďurech.

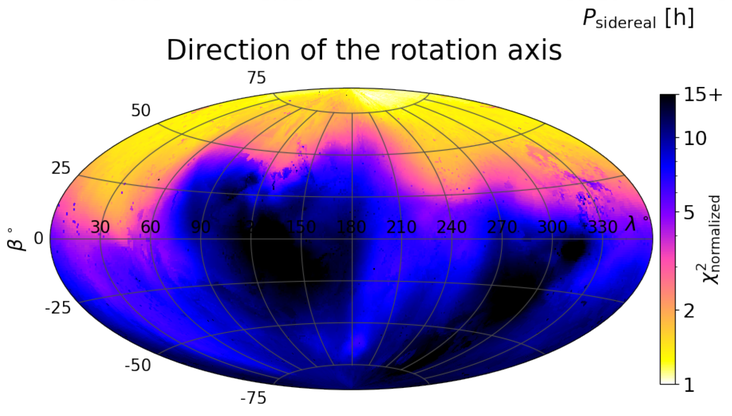
Here we present two examples, namely **(98943) 2001 CC21** with a unique period solution, well constrained pole and convex shape model and **(512245) 2016 AU8** with ambiguous period determination and consecutive limitation on pole solutions. Analysis for a total of 16 asteroids (listed below) will be presented in Fatka et al. (2023).

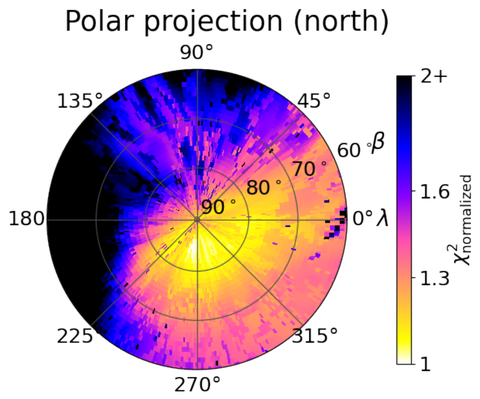
Observed NEAs within NEOROCKS (for spin/shape modeling)			
(5189) 1990 UQ	(6569) Ondaatje	(7482) 1994 PC1	(8566) 1996 EN
(22099) 2000 EX106	(66251) 1999 GJ2	(86450) 2000 CK33	(98943) 2001 CC21
(137199) 1999 KX4	(170891) 2004 TY16	(276786) 2004 KD1	(329437) 2002 OA22
(495615) 2015 PQ291	(506459) 2002 AL14	(512245) 2016 AU8	2013 BO76

(98943) 2001 CC21

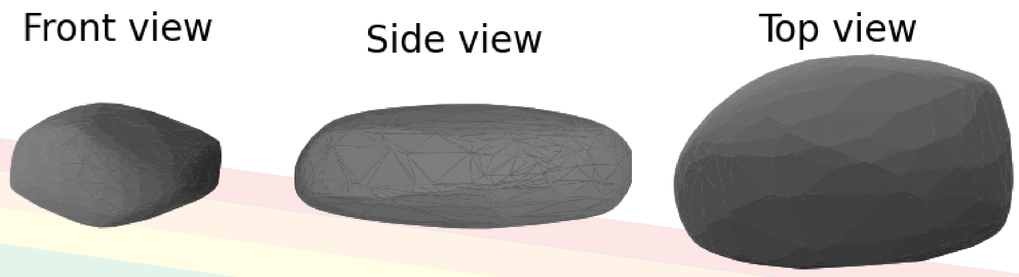
- a = 1.03 au, e = 0.22, i = 4.8°, H = 18.8, S_q-type [3]
- Data from **4 apparitions** 2002 (OA = Ondřejov archive) + 2003 (OA) + 2022 (NEOROCKS) + 2023 (NEOROCKS, ALCDEF) available
- Fly-by in July 2026 by **Hayabusa2#**
- Unique period solution thanks to long observing night runs





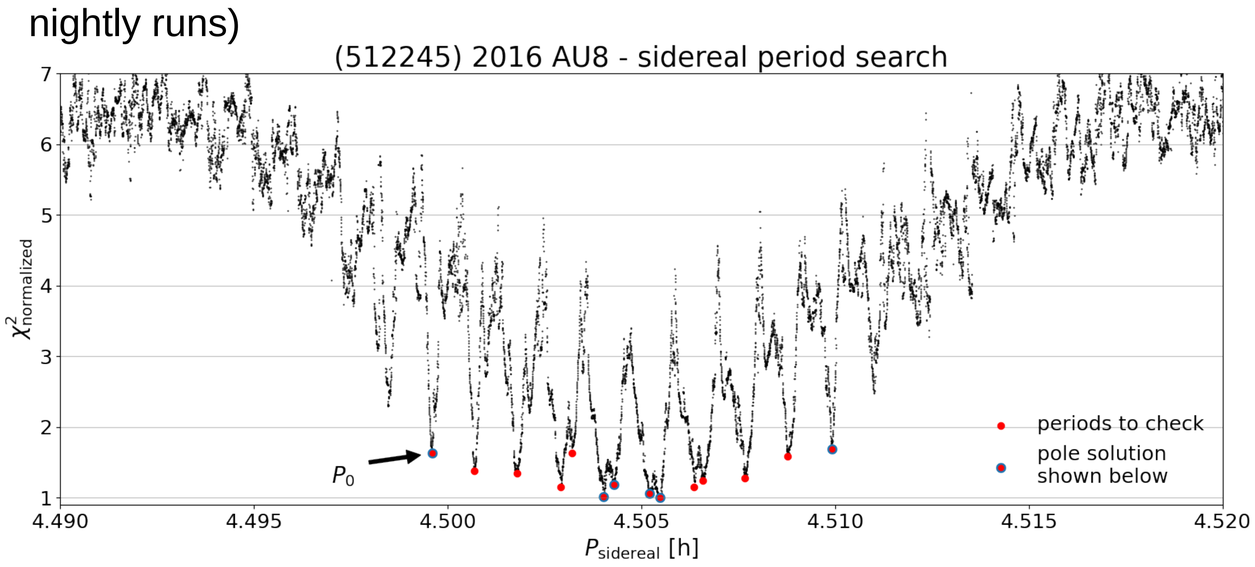


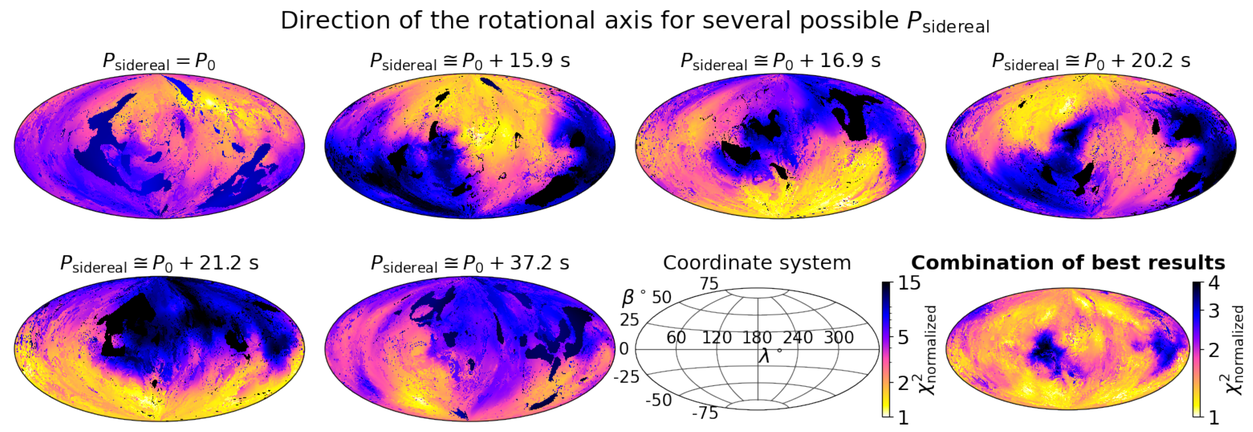
Convex shape model of (98943) 2021 CC21



(512245) 2016 AU8

- a = 0.98 au, e = 0.20, i = 9.2°, H = 19.8, Q-type
- Data from **4 apparitions** 2018/19 (OA) + 2020 (NEOROCKS) + 2021 (NEOROCKS) + 2022 (NEOROCKS)
- Ambiguous sidereal period with several aliases (too short observing nightly runs)





Conclusions

- Despite **each of the two presented asteroids were observed in four apparitions**, we were able to significantly constrain the direction of the rotational axis and approximate its shape for only (98943) 2001 CC21
- **Dense photometric data** in at least some apparitions are needed (example of (98943) 2001 CC21) to get a well constrained model
- Obtaining a unique **sidereal rotational period is essential** for rotational pole and shape derivation
- Model results may differ significantly with only a small period difference
- Observations in at least 3, more often 4 apparitions are typically needed for a meaningful model

References:
[1] Kaasalainen M. and Torppa J., *Optimization Methods for Asteroid Lightcurve Inversion: I. Shape Determination*, Icarus (2001), vol. 153, p. 24-36
[2] Kaasalainen M., Torppa J., and Muinonen K., *Optimization Methods for Asteroid Lightcurve Inversion: II. The Complete Inverse Problem,* Icarus (2001), vol. 153, p. 37-51.
[3] Popescu M. et al., *Spectroscopic and photometric properties of (98943) 2001 CC21, the target of Hayabusa2# space mission*, poster @ PDC2023

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