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# Spectroscopic investigation of asteroids belonging to the Themis and Beagle families

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## Abstract

24 Themis is the largest body of the Themis family. Within this big family a cluster of very young asteroids (age $< 10$ Myr), the Beagle sub-family, has been identified. Recently water ice and organics were detected on 24 Themis indicating that the Themis family may be an important reservoir of ice. Moreover, the main belt comets 133P, 238P, and 176P may be related with the Themis family because of orbital proximities and spectral properties analogies. The aim of this work is to spectroscopically investigate some asteroids belonging to the Themis family and to the young Beagle sub-family in order to look for absorption bands related to water ice, hydrated silicates and organics.

## 1. Introduction

Themis is one of the most statistically reliable family in the asteroid belt. First discovered by Hirayama (1918), it has been identified as a family in all subsequent works, and has 550 members as determined by Zappalà et al. [1]. The Themis family is characterized by asteroids with $3.05 \leq a \leq 3.22$ AU, $0.12 \leq e \leq 0.19$, and $0.7^o \leq i \leq 2.22^o$ [2] and spectrally dominated by primitive C- and B-type asteroids, as reported by spectroscopic investigation in the visible range of some members [3,4]. The family formed probably $\sim$ 2.3 Gyr ago as a result of a large-scale catastrophic disruption event of a parent asteroid $\sim$ 400 km in diameter colliding with a 190 km projectile [5]. Interestingly, recent observations by Rivkin and Emery [6] and Campins et al. [7] found spectroscopic evidence of the presence of water ice and organics on the surface of asteroid Themis. Analyzing the infrared spectrum of the asteroid, Rivkin and Emery [6] concluded that the surface of Themis contains very fine water frost, probably in the form of surface grain coatings, and that the infrared spectral signatures can be fully explained by a mixture of spectrally neutral material, water ice, and organics. Contemporaneously, Campins et al. [7] derived that water ice is evenly distributed over the entire Themis surface using spectra obtained at four different rotational phases. Nevertheless the nature of the 3.1 $\mu$m feature on 24 Themis is still a matter of debate, and very recently Beck et al. [8] proposed the hydrated iron oxide goethite as alternative interpretation of this feature.

The discovery of the presence of water ice and/or hydrated minerals such goethite on 24 Themis indicates that Themis family may be an important reservoir of ice and that possibly ice may exists in the members of its family. Indeed, absorption band in the visible region related to hydrated silicates have been detected on the surface of 15 Themis family members [4]. These materials are produced by the aqueous alteration process, that is a low temperature ($< 320$ K) chemical alteration of materials by liquid water [9]. The presence of hydrated minerals implies that liquid water was once present on these asteroids, and suggest that post-formation heating took place. Of note of evidence is that the main belt comets (MBC) 133P, 238P, and 176P may be related with the Themis family because of orbital proximities and spectral properties analogies. Nesvorny et al [10] propose that 133P potentially be one member of the younger ($< 10$ Myr) Beagle sub-family of the Themis group. This subfamily has 65 members up to 2 km of diameter.

### 1.1. Observations and aims

We started an observational campaign at the TNG telescope devoted to spectroscopically investigate the surface of both 'old' Themis family members and young ones, belonging to the Beagle sub-family. The first run took place on 19-21 february 2012, and additional observing time has been requested for the next semester. We observed 8 Themis and 3 Beagle family member in visible/NIR spectroscopy using the DOLORES (with the LR-R and LR-B grisms) and the NICS instrument (with the Amici prism). To look for possible coma around the targets, we also performed deep imaging in

R filter.
Data are currently under reduction and analysis, and the results will be presented at the Europlanet meeting. We are looking for the presence of absorption bands that may be related to hydrated minerals (at 0.7, 0.6, 0.8-0.9, 1.4 and 1.8 $\mu$m) or to water ice (1.5 and 2 $\mu$m bands).

This research will help constraining the surface composition and thermal evolution of the Themis family members, studying the space weathering effects on primitive asteroids of different ages (by the comparison of the spectral properties of young Beagle family members with non-Beagle 'old' Themis family asteroids), and it will give some hints on the internal structure and composition of the Themis parent body. The results of this study will help us on the understanding of the origin of water on the Earth.

# References

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