VLT/SPHERE Spies
Rocky and Icy Worlds

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ESO Large program on VLT/SPHERE

- ESO Large Program awarded 152h on VLT/SPHERE (PI: P. Vernazza, LAM, FR)

- **Purpose of the LP**: High angular-resolution imaging survey of a representative sample of all $D \geq 100$ km main-belt asteroids (~35 objects; covering the main compositional types) throughout their rotation

- The observations are spread over 4 semesters from April 1st, 2017 till March 30, 2019

- Performed in service mode only with seeing constraint <0.8”
Primordial main belt asteroids: Definition

Primordial (Morbidelli et al. 2009): 
D>~100km

Low macrooporosity 
Density: Powerful constraint of the bulk composition

Rubble piles: 
D<100km

High macrooporosity 
Density: Weak constraint of the bulk composition
Primordial D>100km main belt asteroids: Current knowledge

- There are ~200 MBAs with D>100km (~30 MBAs with D>200km)
- For these bodies, the following properties are well characterized:
  - Orbit
  - Albedo
  - Visible and near-infrared spectrum
- For most of these bodies, mass and 3D shape/volume - hence density - are not well constrained
- For most of these bodies, a surface map of the craters does not exist

=> Few geologic constraints available for these bodies
Output of the survey

- Precise 3D shapes and thus volumes for all targets (<10% error on the volume): 3D shapes produced using the deconvolved images along publicly available optical lightcurves and stellar occultation data using the ADAM algorithm (Viikinkoski et al. 2015)

- These volumes are combined with mass determinations to estimate the density of our targets
  => Constraint of the bulk composition and internal structure of our targets

- The derived 3-D shape models are used to characterize the distribution, size and profile of craters with D>30km. Such information, in turn, allows investigating the collisional history of the targets.

- Potential discovery of new satellites
VLT/SPHERE/ZIMPOL versus VLT/NACO

Angular diameter: 0.42"

Angular diameter: ~0.5"

2 Pallas

Angular diameter: 0.42"

Angular diameter: ~0.5"
Rosetta versus VLT/SPHERE/ZIMPOL

21 Lutetia (seen at a distance of $\sim 7 \times 10^4$ km)

7 Iris (seen at a distance of $\sim 1.35 \times 10^8$ km)
VLT/SPHERE/ZIMPOL versus DAWN/OASIS
The big four seen by VLT/SPHERE/ZIMPOL

1 Ceres

2 Pallas

4 Vesta

10 Hygiea
First results: The impact crater at the origin of the Julia family detected with VLT/SPHERE? (Vernazza et al. 2018)

(89) Julia (D~140km)

Nonza (D~75km)

Julia family:
- 66 members with 1km<D<2.5km
- Age: 30-120 Myrs
- Size of the impact crater: D>60km
- Size of impactor: D~8km
First results: (16) Psyche: A mesosiderite-like asteroid?
(Viinkinkoski et al., submitted to A&A)

Density of Psyche: $3.99 \pm 0.26 \text{ g/cm}^3$
Density of mesosiderites: $4.25 \pm 0.05 \text{ g/cm}^3$
Density of iron meteorites: $\sim 7-8 \text{ g/cm}^3$
Conclusions

New doors into ground-based asteroid exploration, namely geophysics and geology, are being opened thanks to the unique capabilities of VLT/SPHERE.

In the fields of geophysics, geology, and asteroid family studies, the future will only get brighter with the forthcoming arrival of 30–40m class telescopes like ELT, TMT, and GMT.

As soon as papers are accepted for publication, we make the corresponding reduced and deconvolved AO images and 3D shape models publicly available: http://observations.lam.fr/astero/