**Janus: A NASA SIMPLEx mission to explore two NEO Binary Asteroids.**

D.J. Scheeres[1*], J.W. McMahon[1], E.B. Bierhaus[2], J. Wood[2], L.A.M. Benner[3], C.M. Hartzell[4], P. Hayne[1], R. Jedicke[5], L. Le Corre[6], A. Meyer[1], S. Naidu[3], P. Pravec[7], M. Ravine[8] and K. Sorli[1]

*[1]The University of Colorado Boulder, USA (scheeres@colorado.edu); [2]Lockheed Martin Space, USA; [3]Jet Propulsion Laboratory, USA; [4]University of Maryland, USA; [5]University of Hawaii, USA; [6]Planetary Science Institute, USA; [7]Astronomical Institute of the Academy of Sciences, Czech Republic; [8]Malin Space Science Systems Inc, USA*

Janus is a NASA SIMPLEx mission currently in Phase C/D. The SIMPLEx program is designed around the idea of using secondary launch opportunities to explore interplanetary destinations. The Janus mission will be launched with the NASA Psyche mission in August/ September of 2022 and will send two spacecraft to fly by Near Earth Objects of interest. Each of the Janus spacecraft will fly by a binary asteroid system in early 2026. The targeted systems are (175706) 1996 FG3 and (35107) 1991 VH, both of which have been observed repeatedly with photometry, spectrometry and radar (see Figure 1).

The Janus spacecraft are low-cost and small, and are being designed and built by Lockheed Martin (see Figure 2). Each spacecraft carries two science instruments, a visible and an IR imager, built by Malin Space Science Systems (see Figure 3). The spacecraft will perform a rigorous remote sensing campaign when the object is a point source and when resolved. The spacecraft will track the binary asteroid systems through closest approach, allowing for a combination of absolute surface resolution, relative resolution across the target asteroids and phase angle coverage unparalleled in previous asteroid flyby missions (see Figure 4). The science team members all have experience on asteroid missions or are experienced ground based observers of NEAs. The industry team has extensive experience in the design, fabrication and operation of interplanetary spacecraft and instrumentation.

The Janus science goals are to combine flyby observations of the target binary asteroids with ground-based observations, enabling the high resolution imaging and thermal data to be placed into a global context and leveraging all available data to construct an accurate topographical and morphological model of these bodies. Based on these measurements, the formation and evolutionary implications for small rubble pile asteroids will be studied.

The mission has two main science goals, with each having additional science objectives.

**Goal I**: *Identify and understand the processes that lead to binary asteroid formation*.

This goal is achieved by using our flyby observations, in conjunction with ground-based photometry and radar observations, to refine the asteroid component shape models, model their surface topography and morphology, and estimate their dynamical state and constrain their mass distributions. This information will allow different formation theories for binary asteroids to be tested and evaluated against the high resolution Janus data and measurements.

**Goal II**: *Test and evaluate theories for binary asteroid evolution by studying the unique dynamical states of the binary asteroid systems*.

Here we focus on the unique aspects that each of our binary asteroid systems present. Binary 1996 FG3 is in a singly-synchronous state and was the first binary system to be documented to lie in a Binary YORP — Tide equilibrium [1]. Observation of the thermal properties of the secondary will allow us to gain insight into tidal dissipation occurring in the primary body. We will use our thermal and visible mapping of the secondary to estimate these forces acting on the secondary. This will provide the first insight into the tidal dissipation properties of a rubble pile asteroid.

Binary 1991 VH has a secondary that is not settled into the usual, minimum energy singly synchronous state. Instead, the secondary has been seen to exchange angular momentum and energy with the system orbit, leading to an apparent chaotic dynamical evolution [2]. We will use our visible and thermal observations of the secondary and the entire system to better understand why this system is not in a lower-energy state, as most binaries are. Again, there are several hypotheses for why this may be the case, ranging from the system dynamics being close to a resonance between its orbit and spin, to it having been disturbed from a previously settled state by a close planetary flyby. Our observations and resulting models of the 1991 VH system will enable these hypotheses to be tested.

In summary, Janus is a NASA SIMPLEx mission that will launch with the NASA Discovery mission Psyche in August 2022. It's two spacecraft will flyby the target binary asteroids in the first half of 2026. Scientific results from Janus will provide key insights into the mechanics of rubble pile asteroids in general, and binary asteroids in particular.

**References:**
[1] P. Scheirich et al. Icarus 245: 56-63 (2015)
[2] P. Pravec et al. Icarus 267: 267-295 (2016)

**Acknowledgements:** The Janus mission is supported by NASA under a contract from the SIMPLEx Program Office. Part of this research was conducted at the Jet Propulsion Laboratory, California Institute of Technology, under a contract with NASA.

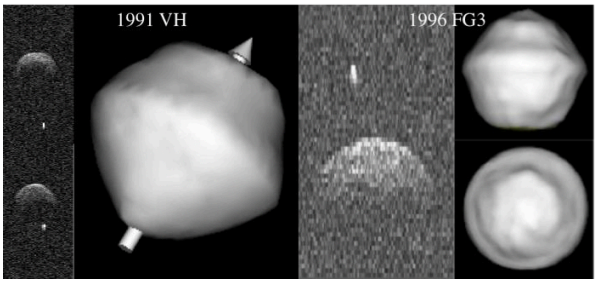


Figure 1: The binary asteroid systems to be targeted have extensive ground-based observations, enabling the high resolution observations taken during flyby to be placed into a global context, and related to many other observed single asteroid systems.

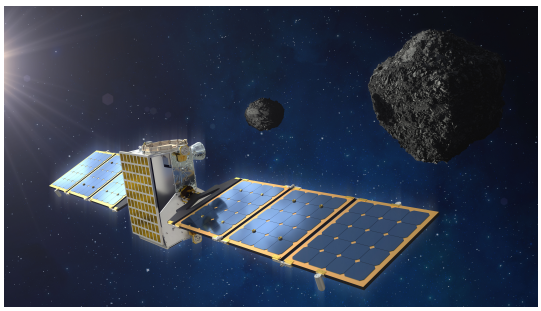

Figure 2: A rendering of the Janus spacecraft during its flyby of one of the target binary asteroids (artist's illustration). Credit Lockheed Martin.

Figure 3: A Mailin Space Science Systems ECAM-M50 (Monochrome) with NFOV (Narrow Field of View) lens (left), ECAM-IR3 (right), and ECAM-DVR4 (center). JCam will appear similar to this shown flight camera system with different lenses. Pocket knife for scale. Credit Malin Space Science Systems.

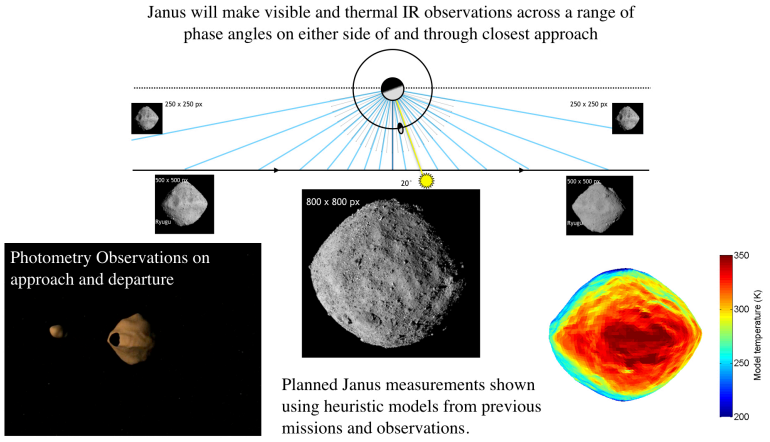


Figure 4: Planned Janus observations during each binary asteroid flyby.