Virtual Workshop
Program and Abstracts

Times listed are U.S. Central Standard Time (GMT -6)

Wednesday, November 4, 2020

9:00 a.m. CST	Session 1: Apophis is Coming! Orbit Dynamics of Apophis' Close Flyby
11:30 a.m. CST	Session 2: Possible Consequences of Earth's Torques or Tidal Stress on Apophis
1:35 p.m. CST	Lightning Talks: Introduction to Day 1 Topic Posters (3 minutes each) View E-Posters
2:00 p.m. CST	Day 1 Social: Virtual Gathering and Conversation

Thursday, November 5, 2020

9:00 a.m. CST	Session 3: Knowledge Opportunities for Earth-Based Assets
11:30 a.m. CST	Session 4: Apophis in the Context of the Near-Earth Object Population
1:00 p.m. CST	Lightning Talks: Introduction to Day 2 Topic Posters (3 minutes each) View E-Posters
1:45 p.m. CST	Open Discussion: Day 2 Topics

Friday, November 6, 2020

9:00 a.m. CST	Session 5: Learning Opportunities from Missions Large and Small
2:15 p.m. CST	Session 6: Guided Discussion — Group Findings and Recommendations for the Path Forward

Print Only

Wednesday, November 4, 2020

SESSION 1: APOPHIS IS COMING! ORBIT DYNAMICS OF APOPHIS' CLOSE FLYBY

9:00 a.m.

Opening session, welcome, and a look at the discovery and orbital dynamics of Apophis' close flyby.

Chairs: Richard Binzel and Patrick Michel

Times (U.S. CST)	Authors (*Denotes Presenter)	Abstract Title and Summary
9:00 a.m.	Michel P., Binzel R. P. *	*Welcome and Workshop Logistics*
9:10 a.m.	Binzel R. P. *	*Apophis T-9 and Counting: Setting the Stage for the Science of Planetary Defense* **[#2022]** Widespread community recognition is emerging for the decadal, if not millennial, opportunity the 2029 Apophis flyby provides for the science of planetary defense. Here we set the stage for the objectives and outcomes of the Apophis T-9 workshop.
9:20 a.m.	Johnson L. N. * Fast K. E. **[INVITED]**	*Discovery of Apophis and Subsequent Impact on NASA'S Planetary Defense Program* **[#2070]** Events surrounding the discovery of Apophis and its affect on NASA's Planetary Defense Program.
9:35 a.m.	Chesley S. R. * Farnocchia D. **[INVITED]**	*Apophis Impact Hazard Assessment and Sensitivity to Spacecraft Contact* **[#2049]** We present a review of the Apophis impact hazard assessment and discuss the implications of spacecraft contacts for future hazard assessments.
9:55 a.m.	Scheeres D. J. * Meyer A. Davis A. B.	*Stationkeeping About Apophis Through Its 2029 Earth Flyby* **[#2025]** Three approaches for a satellite to fly with Apophis through its Earth flyby are investigated: A relative orbit distant from Apophis, hovering along the Earth-Apophis line, or maintaining orbit about Apophis. Each are feasible but challenging.
10:10 a.m.	Margot J. L. * Verma A. K.	*Orbital Evolution of (99942) Apophis Due to the Yarkovsky Effect* **[#2016]** The trajectory of Apophis is strongly affected by the Yarkovsky effect. We determined the Yarkovsky drift rate on the basis of all available astrometry and placed this result in the context of the largest published set of Yarkovsky determinations.
10:25 a.m.	Tholen D. J. * Farnocchia D.	*Detection of Yarkovsky Acceleration of (99942) Apophis* **[#2066]** We've detected Yarkovsky acceleration of Apophis, amounting to a semimajor axis drift rate of -170 meters per year.
10:40 a.m.	Betts B. H. * Dreier C. **[INVITED]**	*Apophis 2029: A Planetary Defense Awareness and Education Opportunity* **[#2040]** Apophis 2029 is a great opportunity to raise awareness and to educate the public and policymakers about the asteroid threat. Putting Apophis resources in place ahead of time will increase awareness, raise excitement, and combat misinformation.
11:00 a.m.		BREAK

Wednesday, November 4, 2020
SESSION 2: POSSIBLE CONSEQUENCES OF EARTH'S TORQUES OR TIDAL STRESS ON APOPHIS
11:30 a.m.
An examination of possible physical effects on Apophis, created by its close encounter.
Chairs: Carol Raymond and Annika Gustafsson

Times (U.S. CST)	Authors (*Denotes Presenter)	Abstract Title and Summary
11:30 a.m.	Scheeres D. J. Benson C. * Brozović M. Chesley S. Pravec P. Scheirich P. **[INVITED]**	*The Abrupt Alteration of Apophis' Spin State and Its Implications* **[#2023]** We analyze Apophis' abrupt spin state evolution using recent optical and radar findings. The 2029 flyby will significantly alter Apophis' spin state. Resurfacing and internal distortion are unlikely. Shifting may occur if Apophis is a contact binary.
11:50 a.m.	DeMartini J. V. * Richardson D. C. Barnouin O. S. Schmerr N. C. Plescia J. B. Scheirich P. Pravec P. **[INVITED]**	*Using a Discrete Element Method to Investigate Seismic Response and Spin Change of 99942 Apophis During the 2029 Tidal Encounter* **[#2032]** We are presenting results from our paper, published last year, about the influence of the Earth's tides on the spin state of Apophis during their 2029 tidal interaction and whether the stresses will produce strains measurable by in-situ seismometers.
12:10 p.m.	Michel P. * Zhang Y.	*Tidal Encounters of Rubble Piles Revisited: Simulations with Soft Spheres and Various Packings* **[#2005]** We revisit tidal encounters by performing simulations with a more realistic numerical treatment of contact forces and frictions between a rubble pile constituent during the encounter, and a more natural internal packing of the modeled rubble pile.
12:25 p.m.	Kim Y. * Hirabayashi M. Binzel R. P. Brozović M.	*The Sensitivity of Apophis' Neck to Resurfacing During the 2029 Earth Flyby* **[#2006]** We numerically investigate the surface evolution and structural failures on Apophis during the 2029 Earth flyby. This study assesses possible regions for resurfacing and its observability through Earth-based telescopes and possible in-situ missions.
12:40 p.m.	Hirabayashi M. * Kim Y.	*Dynamic Finite Element Modeling Approach for the Dynamic Stress Evolution of 99942 Apophis During its 2029 Earth Encounter* **[#2059]** A newly developed dynamic finite element model shows that the pressure in Apophis may vary up to 0.2 Pa on a global scale during the 2029 Earth encounter.
12:55 p.m.	Winter O. C. * Valvano G. Borderes-Motta G. Sfair R. Machado R. Moura T.	*Nearby Dynamics and Surface Characteristics of Apophis* **[#2062]** In the current work we explore two aspects of Apophis: One concerns its surface characteristics taking into account its known irregular shape model, while the other is focused on the dynamical environment nearby it.
1:10 p.m.	Garcia R. F. * Murdoch N. Dehant V. Bernauer F. Schmelzbach C. Igel H. Guattari F. Mimoun D. Lecamp G. Deraucourt S.	*Vibrations and Rotations of Asteroids: Planetary Flyby as an Opportunity for Internal Structure Imaging with 6 Degrees of Freedom Instruments* **[#2017]** Asteroids' seismic vibrations and rotation perturbations are weak in deep space, but can be excited by a planetary flyby. The science case of a 6 degrees of freedom surface instrument is presented, and illustrated with the PIONEERS instrument.
1:25 p.m.		BREAK

Wednesday, November 4, 2020
LIGHTNING TALKS: INTRODUCTION TO DAY 1 TOPIC POSTERS
View E-Posters for access to research being presented during the poster lightning talks.
1:35 p.m.
Posters for Day 1 topics are introduced.
Chairs: Carol Raymond and Annika Gustafsson

Times (U.S. CST)	Authors (*Denotes Presenter)	Abstract Title and Summary
1:35 p.m.	Wlodarczyk I. *	*Possible Impacts of the Asteroid (99942) Apophis* **[#2056]** We compute the possible impacts (99942) Apophis with the Earth using the nongravitational parameter A2.
1:38 p.m.	Pérez-Hernández J. A. * Benet L.	*An Estimation of the Yarkovsky Effect on Asteroid (99942) Apophis via High-Order Taylor Polynomials* **[#2063]** We estimate the Yarkovsky effect for Apophis from optical and radar astrometry exploiting numerical techniques based on Taylor polynomials. We also show how these techniques can be used to propagate orbital uncertainties.
1:41 p.m.	Golubov O. Kopatko A. V. * Strelchenko A. Kyrylenko I. Unukovych V. Krugly Yu. N.	*Yarkovsky Effect for Tumblers and Non-Convex Shapes: Asteroid (99942) Apophis as a Test Case* **[#2072]** We develop the theory of the Yarkovsky effect for tumbling and non-convex asteroids, estimate the importance of these effects for Apophis, and investigate how the collision probability is effected by the uncertainty in the Yarkovsky effect.
1:44 p.m.	Okada T. * Fukuhara T. Yoshikawa M.	*Thermal Imager to Reveal Surface Physical State of Asteroids* **[#2031]** Thermal imaging is a powerful tool to investigate the physical state of planetary surfaces like asteroid Ryugu by TIR on Hayabusa2, so that Apophis should be investigated with thermal imager for science and planetary defense in the future missions.
1:47 p.m.	Sorli K. C. * Hayne P. O.	*Thermophysical Modeling of 99942 Apophis: Estimations of Surface Temperatures During the April 2029 Close Approach* **[#2069]** We utilize a 3-d thermophysical model to estimate surface temperatures of 99942 Apophis during the 2029 close approach. We also propose the use of thermal infrared ground-based observatories during the encounter to validate and refine our models.
1:50 p.m.	Seltzer C. * Peč M. Ghaffari H. O. Binzel R. P.	*Strength of LL Chondrites in Laboratory Deformation Experiments with Applications to Internal Structure of 99942 Apophis* **[#2011]** This experimental work uses lab tests on the acoustic, seismic, and mechanical properties of samples from Kilabo to determine possible internal structure and strength of the asteroid Apophis.

Wednesday, November 4, 2020
DAY 1 SOCIAL: VIRTUAL GATHERING AND CONVERSATION
2:00–3:00 p.m.
Chairs: Richard Binzel and Patrick Michel

Thursday, November 5, 2020

SESSION 3: KNOWLEDGE OPPORTUNITIES FOR EARTH-BASED ASSETS

9:00 a.m.

Exploring the unique opportunities available to Earth-based assets for the science of Planetary Defense.

Chairs: Tomas Kohout and Marcel Popescu

Times (U.S. CST)	Authors (*Denotes Presenter)	Abstract Title and Summary
9:00 a.m.	Barbee B. W. * Sarli B. Lyzhoft J. Nuth J. Purves L. Lewis R. **[INVITED]**	*Key Near-Earth Object Characteristics Measurements for Planetary Defense* **[#2009]** This talk will discuss priorities for near-Earth object characterization for planetary defense purposes, as well as options and considerations for collecting such characterization data via both remote observations and in situ spacecraft observations.
9:20 a.m.	Brozović M. * Benner L. A. M. Naidu S. P. Busch M. W. Giorgini J. D. Taylor P. A. Rivera-Valentin E. G. Virkki A. K. Venditti F. C. F. Marshall S. E. Nolan M. C. Howell E. S. **[INVITED]**	*Radar Reconnaissance of 99942 Apophis* **[#2034]** The flyby of Apophis in 2029 will enable observations using a variety of radar techniques, and may include some that have never been applied to an asteroid previously. This will provide an unprecedented opportunity for scientific discoveries.
9:40 a.m.	Virkki A. K. * Venditti F. C. F. Hickson D. C. Perillat P. Marshall S. E. Taylor P. A. Herique A.	*Bistatic Arecibo Planetary Radar Observations of 99942 Apophis* **[#2013]** Planetary radar observations provide a strong tool to characterize near-Earth objects. We discuss how ground-based radar observations can contribute in the characterization of 99942 Apophis during its close approach in April 2029.
10:00 a.m.	Herique A. * Plettemeier D. Kofman W. Zine S. Gassot O. Rogez R. Michel P. Ulamec S. Biele J. Ho T. R. Grundmann J. T. Perna D. Goldberg H. Virkki A. Venditti F. C. F. Marshall S. E. Hickson D. C.	*Direct Observation of 99942 Apophis with Radar* **[#2029]** Direct measurements of Apophis deep interior and regolith structure are crutial to understand accretion and tidal effects. The paper reviews possible strategies to probe Apophis with onboard radars. It proposes relevant instrument suite.
10:15 a.m.	Nolan M. C. * Benner L. A. M. Brozović M. Busch M. W. Giorgini J. D. Hickson D. C. Howell E. S. Marshall S. E. Naidu S. P. Rivera-Valentin E. G. Taylor P. A. Venditti F. C. F. Virkki A. K.	*Multiwavelength RADAR Observations of Apophis* **[#2045]** The long and the short of RADAR observations of Apophis.
10:30 a.m.	Moskovitz N. A. * Devogele M.	*Observing Apophis in 2029: Lessons from Other NEO Fly-Bys* **[#2014]** We will discuss examples of recent NEO encounters and associated ground-based observational campaigns, lessons learned from these campaigns, and an outline of infrastructure needs to maximize the scientific return during the Apophis flyby.

10:45 a.m.	Grundmann J. T. * Fexer S. Laabs M. Plettemeier D.	*Apophis and the Waves: The Need for Frequency Coordination and Radio Amateur and University Community Support Before, During, After Close Approach* **[#2073]** We intend to start the discussion to include the public in the unique observation of Apophis, in particular focusing on the radio amateur community and the need for world-wide coordination to avoid mutual interference.
11:00 a.m.		BREAK

Thursday, November 5, 2020

SESSION 4: APOPHIS IN THE CONTEXT OF THE NEAR-EARTH OBJECT POPULATION

11:30 a.m.

We take advantage of our existing knowledge of the near-Earth object population, meteorites, and techniques for spectral modeling.

Chairs: Nicholas Moskovitz and Cristina Thomas

Times (U.S. CST)	Authors (*Denotes Presenter)	Abstract Title and Summary
11:30 a.m.	Licandro J. * Popescu M. Oscoz A. de Leon J. Zamora O. Monelli M.	*Visible Spectroscopy of NEAs in the Framework of the ESA-SSA P3NEOI Program* **[#2030]** We present the preliminary results of the spectroscopic campaign of NEAs using the Roque de los Muchachos Observatory telescopes in the framework of the ESA-SSA P3NEOI project, started in April 2019.
11:45 a.m.	Gustafsson A. * Moskovitz N.	*Revealing Regolith Properties of Near-Earth Asteroids* **[#2042]** Our work will allow for the implementation of radiative transfer modeling on visible and near-infrared spectra of unresolved silicate-rich asteroids using Hapke modeling to constrain physical characteristics of the surface, including grain size.
12:00 p.m.	Hsu H.-W. * Wang X. Horanyi M.	*Electrostatic Removal of Fine-Grained Regolith on Sub-km Asteroids* **[#2044]** We show that sub-km sized asteroids near 1 AU experience a net loss of fine-grained regolith driven by electrostatic forces, implying that Apophis likely shows a desert pavement-like scenery, as seen on other similar-sized asteroids.
12:15 p.m.	Burkey M. T. * Bruck Syal M. Managan R. A. Owen J. M. Dearborn D. S. P.	*Asteroid Deflection: Sensitivity to Material Properties* **[#2046]** Asteroid deflection simulations depend upon material property assumptions, and many properties of NEAs remain poorly constrained. We present sensitivities to various parameters, in order to inform potential Apophis characterization missions.
12:30 p.m.	Campins H. Cantelas R. * Popescu M. Tatsumi E. de Leon J. Licandro J. Rizos J. L. DellaGiustina D. Kaplan H.	*Possible Exogenous Material on Asteroid Apophis* **[#2035]** Exogenous material could be detectable on asteroid Apophis; the likelihood of such a detection has increased based on recent observations. Here, we review this topic and consider the implications of detecting exogenous material on Apophis.
12:45 p.m.		BREAK

Thursday, November 5, 2020

LIGHTNING TALKS: INTRODUCTION TO DAY 2 TOPIC POSTERS

View E-Posters for access to research being presented during the poster lightning talks.

1:00 p.m.

Posters for Day 2 topics are introduced.

Chairs: Nicholas Moskovitz and Cristina Thomas

Times (U.S. CST)	Authors (*Denotes Presenter)	Abstract Title and Summary
1:00 p.m.	Nolau J. O. * Swindle T. D. Campins H. Connolly H. C. Jr.	*How Unique is Almahata Sitta and How Relevant is It to Bennu?* **[#2067]** How rare are meteoritic falls like Almahata Sitta (in 2008) that contain different classifications within its strewn field? How relevant is Almahata Sitta to Bennu?
1:03 p.m.	Zhang Y. *	*Origin of 1I/'Oumuamua: A Tidal Disruption Fragment* **[#2018]** We show that 'Oumuamua can be formed and ejected by tidal encounters with its host star, and highlight the high occurrence rate of tidal encounters around stars. Monitoring the close approach of Apophis can reveal similar processes in other systems.
1:06 p.m.	Popescu M. * Vaduvescu O. de León J. de la Fuente Marcos C. de la Fuente Marcos R. Licandro J. Pinter V. Zamora O.	*Physical Characterization of 2020 AV2, the First Known Asteroid Orbiting Inside Venus Orbit* **[#2021]** 2020 AV2 is the first known asteroid orbiting inside Venus orbit. Its properties are a peculiar case compared with those of the NEAs. We report spectral data over (0.5, 1.5) um. We found a surface composition similar with olivine-rich asteroids.
1:09 p.m.	Cahill J. T. S. * Greenhagen B. T. Kenyon M. Mariani G. Lucey P. G.	*Characterization of Asteroid Thermal Environments and Physical Properties for Exploration and Planetary Defense Using Advanced Thermopile Arrays* **[#2037]** Thermal infrared capabilities will be a key technology necessary for evaluating the thermophysical properties of PHA's. Here we discuss scenarios in which they may be utilized during a mission to examine Apophis during its flyby of Earth.
1:12 p.m.	Liu P.-Y. * Campo Bagatin A.	*Numerical Orbital Simulation for a Spacecraft to Rendezvous Two NEOs — Apophis and 2001 WN5* **[#2057]** The aim of this work is to find an orbit for a spacecraft to rendezvous both Apophis and 2001 WN5, which can be used to set up a future space mission. The simulation is performed using the N-body orbital simulator MERCURY 6.2 package.
1:15 p.m.	Aljbaae S. * Sanchez D. M. Prado A. F. B. A. Souchay J. Terra M. O. Negri R. B. Marchi L. O.	*Close Proximity Motion Relative to (99942) Apophis* **[#2061]** We provide a generalized discussion on the dynamics of a spacecraft near to Apophis during its Earth close approach, considering the solar radiation pressure. The polyhedral shape of the target is used to accurately model the gravitational field.
1:18 p.m.	Edwards B. * Savini G. Tinetti G. Tessenyi M. Stotesbury I. Archer R. Joshua M. Wilcock B.	*Twinkle: A Space-Based Observatory for Visible and Near-Infrared Spectroscopy* **[#2027]** Twinkle, a space-based observatory with a primary mirror diameter of 0.45 m, will be capable of simultaneously obtaining visible and near-infrared spectra (0.5-4.5 micron) and could be used for characterising Apophis just before its closest approach.

1:21 p.m.	Polishook D. *	*Post-Flyby Observations of Apophis from the Moon* **[#2026]** Apophis will not be seen by Earth's optical telescopes after the flyby. Placing a small-sized telescope on the Moon could measure changes in Apophis spin. It could reach the Moon as a scientific payload of one of NASA's Artemis project missions.
1:24 p.m.	Melikyan R. * B. E. Clark C. Hergenrother	*An Estimate of the Flux of Apophis-Particle Meteors at Earth* **[#2075]** Recently discovered by the OSIRIS-REx Spacecraft at asteroid Bennu, the near-Earth asteroid population may all be subject to the mechanisms responsible for mass-loss from Bennu. We present initial results from a potential Apophis meteoroid stream.

Thursday, November 5, 2020
OPEN DISCUSSION: DAY 2 TOPICS
1:45–2:15 p.m.
Chairs: Richard Binzel and Patrick Michel

Friday, November 6, 2020
SESSION 5: LEARNING OPPORTUNITIES FROM MISSIONS LARGE AND SMALL
9:00 a.m.
Mission objectives and instrumentation concepts for Apophis and the science of Planetary Defense.
Chairs: Marina Brozovic and Anne Virkki

Times (U.S. CST)	Authors (*Denotes Presenter)	Abstract Title and Summary
9:00 a.m.	Rivkin A. S. *	*Why We Should, and Should Not, Visit Apophis* **[#2028]** To have the greatest chance of support and success, an Apophis mission must focus on goals that are uniquely or best achieved at that body, and stay away from investigations that could be achieved at any generic asteroid.
9:15 a.m.	Raymond C. A. * Bell III J. F. Park R. S. Landau D. Chesley S. R. Reh K. Chodas P. W. Brozoviā M.	*Potential Mission Concepts for Characterizing the Potentially Hazardous Near-Earth Asteroid (99942) Apophis* **[#2048]** The extremely close flyby of (99942) Apophis is a unique opportunity to characterize a near-Earth object subjected to tidal forcing. A range of mission concepts are considered that provide full characterization of Apophis and would apply to any PHA.
9:30 a.m.	Daly R. T. * Barnouin O. S. Cheng A. F. Plescia J. B. Richardson D. C. DeMartini J. V. Schmerr N. C. Sunshine J. M. Ernst C. M. Denevi B. W. Cahill J. T. Davis A. K. Chabot N. C. Lauretta D. S.	*The Planetary Defense and Science Case for a Mission to Study Apophis Before, During, and After Its Closest Earth Approach in 2029* **[#2043]** Apophis' close approach in nine years does not, in and of itself, justify sending a spacecraft. Two factors, however, compellingly motivate a mission to Apophis.
9:45 a.m.	Cheng A. F. * Daly R. T. Barnouin O. S. Plescia J. B. Richardson D. C. DeMartini J. V. Schmerr N. C. Sunshine J. M. Ernst C. M. Denevi B. W. Cahill J. T. S.	*Apophis 2029 Planetary Defense Mission Options* **[#2015]** The 2029 Apophis Earth flyby is a unique opportunity to obtain vital information for planetary defense by studying Apophis, determining its internal structure, and observing possible changes due to tidal effects from the Earth flyby.
10:00 a.m.	Chand S. * Grundmann J. T.	*Low Thrust: The Fast and Flexible Path to Apophis* **[#2071]** We propose the use of already created low-thrust trajectories to Apophis to help advance design trades in the early study phases of missions to Apophis. It appears that small spacecraft missions could benefit from solar-electric or sail propulsion.
10:15 a.m.		BREAK
10:30 a.m.	Lauretta D. S. * Bierhaus E. B. Binzel R. P. Bos B. J. Christensen P. R. Chesley S. R. Daly M. G. DellaGiustina D. N. Drouet d'Aubigny C. Farnocchia D. Hamilton V. E. Reuter D. C. Rizk B. Simon A. A. Sutter B. M.	*OSIRIS-REx at Apophis: Opportunity for an Extended Mission* **[#2008]** We developed a mission design that allows us to put the OSIRIS-REx spacecraft into orbit around asteroid (99942) Apophis in 2029. This opportunity allows for OSIRIS-REx to characterize this potential asteroid, comparable to that achieved at Bennu.

10:45 a.m.	Moon H.-K. * Choi Y.-J. Kim M.-J. JeongAhn Y. Yang H. Jeong M. Ishiguro M. Baek S.-M. Choi J. Sim C. K. Lee D. Park S.-Y. Kim P. Kwon S.-J. Shin G.-H. Ryu K.-S. Kim S.-G. Lee J.-S. Seo J.-G. Kim S.-Y. Kim D.-G. Shin I.-H. Park S.-O. Chung T.-J. Shin G.-S. Choi H.-T. Yoon H.-S. **[INVITED]**	*Apophis Rendezvous Mission for Scientific Investigation and Planetary Defense* **[#2065]** We propose a rendezvous mission to Apophis to monitor the target before, during, and after the encounter to see if there are any significant changes in spin and the surface. If the budget is secured, the mission will start in the year 2022.
11:00 a.m.	Prado J. Y. * Hestroffer D. Herique A.	*APOPHIS Express, a Unique Opportunity for Visiting APOPHIS in 2029* **[#2050]** The mission scheme that is proposed consists in a very fast mission, less than one month, from the launch to the delivery of a scientific payload on Apophis surface, with a possible sample return option.
11:15 a.m.	Barbee B. W. * Lim L. F. Aslam S. Sarli B. Lyzhoft J. Hewagama T. Nuth J. Liounis A. Nakamura R. Hughes K. Purves L. Lewis R.	*Reconnaissance of Apophis (RA): A Mission Concept for Exploring the Potentially Hazardous Asteroid Apophis During Its 2029 Earth Encounter* **[#2010]** This talk describes a concept currently in development for a small spacecraft mission (<180 kg) to study Apophis before, during, and after the 2029 Earth encounter.
11:30 a.m.		BREAK
12:00 a.m.	Smith D. E. * Sun X. Mazarico E. Cremons D. Zuber M. T. Neumann G. A. Goossens S. J. Barker M. K. Mao D. Head J. W.	*A Mission Concept for Measuring Changes in Apophis During Earth Encounter* **[#2003]** A mission concept for a small space-craft to rendezvous with Apophis, deploy a simple passive tracking device on the surface, and co-orbit the sun with the asteroid for several years making observations of the surface, its structure, and rotation.
12:15 p.m.	Scheld D. * Dreyer C. Durda D. Farrand B. Abell P.	*Charming Apophis — HUMMINGBIRDsCHARM (HsC) Interview with Apophis* **[#2074]** If the dynamics allow for a rendezvous, then there is potential for an HsC primary vehicle rendezvous and “potential” for release of multiple Hummingbirds. This would be detailed remote sensing with the ability to explore the surface, but short of sample return.
12:30 p.m.	Lange C. Ho T.-M. Grundmann J. T. * Chand S.	*This is What a MASCOT Can Do for You — at Apophis* **[#2068]** We outline the capabilities of the asteroid nanolanders MASCOT, MASCOT2, and the options for optimized MASCOT@Apophis designs in particular for small spacecraft rendezvous missions to Apophis.
12:45 p.m.	McMahon J. W. * Keplinger C. M.	*Area-of-Effect Softbots (AoES) for Surface Science During Planetary Flyby* **[#2036]** A new soft-robotic platform – AoES – which are being developed under a NIAC grant are presented for use in measuring change in Apophis’ surface and spin during flyby.

1:00 p.m.	Sava P. * Asphaug E.	*Non-Contact Seismology on Asteroid 99942 Apophis* **[#2019]** Laser Doppler vibrometers could be used to collect seismic data for 3D deep interior imaging of small planetary bodies like 99942 Apophis. LDVs are simple and robust, operate remotely from stable orbiters, and sample motion at many surface locations.
1:15 p.m.	Bell J. F. III * Papsidero L.	*Apophis Pathfinder: A Smallsat Mission to Investigate the Potentially Hazardous Near Earth Asteroid (99942) Apophis* **[#2060]** The MILO Institute's Apophis Pathfinder smallsat mission would perform a close flyby of (99942) Apophis up to 3 to 5 years before its historic 2029 Earth flyby, providing advance data on the asteroid's characteristics to inform the 2029 missions.
1:30 p.m.	Kohout T. * Näsilä A. Goldberg H. Koschny D. Lehtinen T.	*Is the Technology Ready for a CubeSat Apophis 2029 Mission?* **[#2039]** In this study, we will evaluate the feasibility of designing a low-cost Apophis 2029 mission utilizing current or forthcoming CubeSat technology.
1:45 p.m.	Liao Y. * Chu E. P. Huang C. Lai I. L.	*PHACE: Potentially Hazardous Asteroid CubeSat Exploration Mission* **[#2007]** We propose a 6U CubeSat mission PHACE (Potentially Hazardous Asteroid CubeSat Exploration) to investigate the asteroid 99942 Apophis during 2029. PHACE aims to rendezvous with Apophis and take in-situ measurements with a camera and NIR spectrometer.
2:00 p.m.		BREAK

Friday, November 6, 2020
SESSION 6: GUIDED DISCUSSION —
GROUP FINDINGS AND RECOMMENDATIONS FOR THE PATH FORWARD
2:15 p.m.
Chairs: Richard Binzel and Patrick Michel

Times (U.S. CST)	Authors (*Denotes Presenter)	Abstract Title and Summary
2:15 p.m.	Binzel R. P., Michel P. *	*Guided Discussion — Building the Case for the Path Forward*
3:15 p.m.		*End of Workshop*

PRINT ONLY

BACK TO TOP

Authors (*Denotes Presenter)	Abstract Title and Summary
Johnson P. A. Johnson J. C. Mardon A. A.	*Considerations for the Application of Probes for Mineral Sampling on Apophis* **[#2001]** Our group previously examined design considerations for motor units of space probes and unmanned aerial vehicles for use in Mars missions as well as on asteroids. We hereby extend these design considerations to its use for the 2029 99942 Apophis.
Johnson P. A. Johnson J. C. Mardon A. A. Fisher J. Zirnov S. Santhosh D. Zhou G.	*Ultraviolet Imaging and Composite Infrared Spectrometers for the Measurement of Apophis Effects on Earth's Atmosphere* **[#2052]** Ultraviolet Imaging Spectrometry and Composite Infrared Spectrometry are two techniques, which could be utilized for the detection and monitoring changes in the Earth's atmosphere (magnetosphere, ignorosphere, thermosphere) for the Apophis fly-by.
Cloutis E. A. *	*A Re-Evaluation of Olivine-Pyroxene Spectral Calibrations and Implications for Apophis* **[#2012]** Understanding the physical and compositional properties of Apophis will benefit from new analyses of mafic silicate mixtures and LL chondrites reflectance spectra.