Harold F. Levison

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PERSONAL BACKGROUND

Home Address:
634 Emery Street
Longmont, CO 80501 USA
1 (303) 682-1251

Born:
March 1, 1959 in Philadelphia, Pennsylvania, USA.

Family Status:
Married to Sarah A. Sulka, June 7, 1981.
Two Children: Rachel S. Levison born September 11, 1994
Shaina E. Levison born September 19, 1997.

EDUCATION

Ph.D. (Astronomy), The University of Michigan, Ann Arbor, Michigan, 1986.
Thesis Topic: *Scale-Free Models of Highly Flattened Elliptical Galaxies*
(Advisor: D.O. Richstone).

M.S. (Astronomy), The University of Michigan, Ann Arbor, Michigan, 1983.

A.B. (Physics with honors), Franklin and Marshall College,
Lancaster, Pennsylvania, 1981.

EMPLOYMENT

Southwest Research Institute, Department of Space Studies
November 1992 – Present. Current title: Institute Scientist

U.S. Naval Observatory, Orbital Mechanics Department, Washington, DC
April 1991 – November 1992.

U.S. Naval Observatory, Flagstaff Station,
September 1988 – March 1991.

National Research Council Postdoctoral Research Associateship,
NASA Ames Research Center, September 1986 – August 1988.

Visiting Lecturer, Astronomy Department, The University of Michigan,
May 1986 – July 1986.

Teaching Assistant, Astronomy Department, The University of Michigan,
May 1982 – May 1986.

Research Assistant/Instrument Development, Astronomy Department,
The University of Michigan, June 1981 – December 1983.

Planetarium Director, North Museum, Lancaster, Pennsylvania,
September 1977 – May 1981.

INVITED TALKS

Summary:
Since January 2007, Levison has given 23 invited talks at international workshops and meetings, 15 colloquia at major astronomical institutions, and 8 E/PO presentations. A complete list can be found at `http://www.boulder.swri.edu/~hal/talks.html`.

Recent Invited Talks:

The 11^{th} Hellenic Astronomical Conference, Anthens, Greece, 2013
Title: *Tackling Some Issues in Planet Formation — From Mars's Size to a Fast Formation of Neptune*

Goldschmidt 2013: Session on Planet Formation and Bomdardment, Florence
Title: *The Formation of the Cores of the Giant Planets*

Large-Scale simulation of Formation and Evolution of Planetary Systems: Kobe 2013 Summer Workshop
Title: *Tackling Some Issues in Planet Formation — From Mars's Size to a Fast Formation of Neptune*

Pluto Science Conference 2013, Laurel MD, USA
Title: *Unraveling the Early Dynamical Evolution of the Outer Solar System A Decade of the Nice Model*

Formation and Evolution of Moons, Noordwijk, The Netherlands, 2012
Title: *The Formation of Pluto's Small Satellites.*

In Situ Science and Instrumentation for Primitive Bodies, Pasadena, CA, USA, 2012
Title: *New Dynamics of Solar System Formation and Migration*

Workshop on the Dynamics and Formation of the Oort Cloud, Lille, France, 2011
Title: *Dynamical Origin of Comet Families*

Origin of Earth's Water Workshop, Breiddalsvik, Iceland, 2011
Title: *The New Dynamics of Solar System Formation*

MISSION PARTICIPATION

Whipple: Levison is the *Science Team Lead* for the proposed mission "Whipple: Reaching into the Outer Solar System". The Whipple mission will conduct a blind survey for occultations of bright stars by small, distant objects. This technique can detect objects from the Kuiper belt to the Oort Cloud. Whipple was proposed to NASA in 2010 in response to the SMD Discovery AO, and was selected for "further technology development". It will be submitted again in the next round of proposals.

GRANTS

Summary: Since arriving at SwRI, Levison has submitted 30 proposals to either NASA or the NSF. Of these, 28 were funded. This constitutes a 93% success rate.

Current Funding

NSF:

Title: *Giant Planet Core Formation*

Abstract: Jupiter and Saturn present one of the most challenging problems in planet formation. These planets, which are made mainly of hydrogen and helium, must have accreted this gas from the solar nebula. Observations of young star systems suggest that these gas disks have lifetimes of $\sim 1 - 10$ Myr. The leading theory for the formation of Jupiter and Saturn is the so-called *core accretion model*. In this model a large planetary embryo forms first, mainly by two-body accretion. This is followed by a period of inflow of nebular gas directly onto the growing planet. Assembling a core before the nebula disappears, it turns out, offers a serious challenge to the theory of planet formation as it currently stands. In this program, we are contructing the most extensive model of core accretion to date using a new state-of-the-art N-body code known as LIPAD.

PI: H. Levison

Funding: **$420,166** over 3 years.

NASA's Origins of Solar Systems Program

Title: *The Early Dynamical Evolution of the Solar System*

Abstract: This program is the latest installment of a 20 year effort to study the formation and long-term dynamical behavior of the Solar System and its constituent bodies. The research in this cycle has a unifying theme: to understand the role that small bodies played in determining the current anatomy of the outer Solar System. Within the context of this grant, we plan to address: 1) the origin and evolution of the scattered disk and Oort cloud, 2) to extend and further develop the so-called 'Nice Model' of the early dynamical evolution of the outer Solar System as a whole, and 3) to study a new idea for the formation of Iapetus which could explain its ridge and equatorial bulge.

PI: H. Levison

Funding: **$344,000** over 3 years

NASA's Outer Planet Research Program

Title: *Study of Small Bodies in the Outer Solar System*

Abstract: The Solar System is inhabited by a myriad of smaller bodies made up of rock and ice. These objects mainly reside in a number of reservoirs that are found in the dynamically long-lived niches scattered throughout the planetary system. These reservoirs are scientifically interesting not only for their own sake, but because they are likely to supply crucial clues to unraveling the dynamical evolution of the Solar System as a whole. This program consists of three focused tasks whose goals are to shed light on some particular aspect of Solar System evolution — either currently or in the distant past. They are: 1) a project to understand the origin and dynamical evolution of the Oort cloud, 2) a project to determine how comet 2P/Encke arrived on its strange orbit, and 3) a project to determine why binarity in the Kuiper belt is a strong function of inclination.

PI: H. Levison

Funding: **$404,394** over 4 years.

NASA's Astrobiology Institute

Title: *Origin and Evolution of Organics in Planetary Systems: Theme 1.3 Dynamical Transport*

Abstract for Entire Institute: Did delivery of carbon-containing molecules and water to the early Earth enable the emergence and evolution of life? If so, how did it happen? What were the processes involved in the creation of such molecules? These are some of the driving questions behind the research that is performed at the Goddard Center for Astrobiology. Our scientists focus on various aspects of exogneous materials, from the formation of complex organic materials on ice grains to the delivery of those primordial materials to the Earth, starting in the early bombardment period and continuing until today. A critical assessment requires investigations of very diverse topics. Our research encompasses four themes: 1) From Icy Planetesimals to Planets: Organics as a Key Window into Early Planetary Systems, 2) From Molecular Cores to Planets: Our Interstellar Organic Heritage. 3) Organic Compounds in Extraterrestrial Materials and Laboratory Analogues. Analytical Protocols and Techniques for Planetary Organics

PI: M. Mumma (GSFC). (H. Levison CoI)

Funding for Levison's subcontract: **$299,727** for 4 years.

NASA's Lunar Science Institute

Title: *Understanding the Formation and Bombardment History of the Moon*

Abstract: The dramatic Apollo exploration of the Moon concluded in the early 1970s. Three fundamental scientific concepts emerged from this historic venture that profoundly changed our understanding of how objects like our Moon form and evolve. These ideas are: (1) lunar origin by giant impact, (2) the existence of an early lunar magma ocean, and (3) the potential of an impact cataclysm at 3.9 billion years ago (Ga). As often occurs with scientific discovery, however, these ideas have raised more questions than they have answered. We have formed the multi-institution Center for Lunar Origin and Evolution (CLOE) in order to bring what has been a true revolution in our understanding of how our planetary system formed and evolved to bear on the fundamental issues of the geophysical/geochemical make-up of the Moon and the lunar cratering record. This can only be accomplished by adopting a multi-disciplinary approach that extends our research beyond its traditional limits. In turn, CLOE brings to the NLSI unparalleled expertise to inform planetary science of the unique implications of the Moon for the rest of the solar system. CLOEs research comprises three scientific themes. 1) "Formation of the Moon, where we are modeling the giant impact through to the end of the Moons accumulation. 2) "Observational Constraints on the Bombardment History of the Moon, were we are employing inventive techniques to deduce new physical constraints on impact rates throughout lunar history. 3) "Modeling Lunar Impact Rates, were we are developing the most complete model to date of the lunar cratering rate from the pre-LHB era to the present.

PI: W. Bottke (SwRI). (H. Levison CoI and Theme 3 lead)

Funding: $6,384,300 for 4 years (**$750,233** for Levison)

Publications

Summary: Levison has published 123 refereed articles. He was the first author of 38 of these. These appeared in:

Astronomical Journal: 30

Astrophysical Journal: 16 (5 were letters)

Icarus: 44

Nature: 11

Science: 5

According to Google Scholar, there have been 13,014 references to his work (11,492 without Monet *et al.* 2003, in which he had little input). His i10-index is 114, and his h-index is 54.

Bibliography:

Minton, D. A., & Levison, H. F. 2013. Planetesimal-Driven Migration of Terrestrial Planet Embryos. *Icarus,* submitted.

Levison, H. F., Duncan, M. J., Thommes, E. 2012. A Lagrangian Integrator for Planetary Accretion and Dynamics (LIPAD). *The Astronomical Journal* **144**, 119.

Grundy, W. M., and 11 colleagues 2012. Mutual events in the Cold Classical transneptunian binary system Sila and Nunam. *Icarus* **220**, 74.

Stansberry, J. A., Grundy, W. M., Mueller, M., Benecchi, S. D., Rieke, G. H., Noll, K. S., Buie, M. W., Levison, H. F., Porter, S. B., Roe, H. G. 2012. Physical properties of trans-neptunian binaries (120347) Salacia-Actaea and (42355) Typhon-Echidna. *Icarus* **219**, 676.

Bottke, W. F., Vokrouhlický, D., Minton, D., Nesvorný, D., Morbidelli, A., Brasser, R., Simonson, B., Levison, H. F. 2012. An Archaean heavy bombardment from a destabilized extension of the asteroid belt. *Nature* **485**, 78.

Kretke, K. A., Levison, H. F., Buie, M. W., Morbidelli, A. 2012. A Method to Constrain the Size of the Protosolar Nebula. *The Astronomical Journal* **143**, 91.

Brasser, R., Duncan, M. J., Levison, H. F., Schwamb, M. E., Brown, M. E. 2012. Reassessing the formation of the inner Oort cloud in an embedded star cluster. *Icarus* **217**, 1.

Levison, H. F., Morbidelli, A., Tsiganis, K., Nesvorný, D., Gomes, R. 2011. Late Orbital Instabilities in the Outer Planets Induced by Interaction with a Self-gravitating Planetesimal Disk. *The Astronomical Journal* **142**, 152.

Levison, H. F., Walsh, K. J., Barr, A. C., Dones, L. 2011. Ridge formation and de-spinning of Iapetus via an impact-generated satellite. *Icarus* **214**, 773.

Grundy, W. M., Noll, K. S., Nimmo, F., Roe, H. G., Buie, M. W., Porter, S. B., Benecchi, S. D., Stephens, D. C., Levison, H. F., Stansberry, J. A. 2011. Five new and three improved mutual orbits of transneptunian binaries. *Icarus* **213**, 678.

Nesvorný, D., Vokrouhlický, D., Bottke, W. F., Noll, K., Levison, H. F. 2011. Observed Binary Fraction Sets Limits on the Extent of Collisional Grinding in the Kuiper Belt. *The Astronomical Journal* **141**, 159.

Capobianco, C. C., Duncan, M., Levison, H. F. 2011. Planetesimal-driven planet migration in the presence of a gas disk. *Icarus* **211**, 819.

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Levison, H. F., Duncan, M. J., Brasser, R., Kaufmann, D. E. 2010. Capture of the Sun's Oort Cloud from Stars in Its Birth Cluster. *Science* **329**, 187.

Benecchi, S. D., Noll, K. S., Grundy, W. M., Levison, H. F. 2010. (47171) 1999 TC_{36}, A transneptunian triple. *Icarus* **207**, 978.

Booth, M., Wyatt, M. C., Morbidelli, A., Moro-Martín, A., Levison, H. F. 2010. How Common are Extrasolar, Late Heavy Bombardments?. *Pathways Towards Habitable Planets* **430**, 407.

Nesvorný, D., Jenniskens, P., Levison, H. F., Bottke, W. F., Vokrouhlický, D., Gounelle, M. 2010. Cometary Origin of the Zodiacal Cloud and Carbonaceous Micrometeorites. Implications for Hot Debris Disks. *The Astrophysical Journal* **713**, 816.

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‡ Morbidelli, A., Levison, H. F. 2008. Late evolution of planetary systems. *Physica Scripta Volume* **T 130**, 014028.

Brasser, R., Duncan, M. J., Levison, H. F. 2008. Embedded star clusters and the formation of the Oort cloud. III. Evolution of the inner cloud during the Galactic phase. *Icarus* **196**, 274.

Levison, H. F., Morbidelli, A., Van Laerhoven, C., Gomes, R., Tsiganis, K. 2008. 'Origin of the Structure of the Kuiper Belt during a Dynamical Instability in the Orbits of Uranus and Neptune.' *Icarus* **196**, 258.

‡ Duncan, M. J., Brasser, R., Dones, L., Levison, H. F. 2008. The Role of the Galaxy in the Dynamical Evolution of Transneptunian Objects. In *The Solar System Beyond Neptune,* eds. M. A. Barucci, H. Boehnhardt, D. P. Cruikshank, & A. Morbidelli (Tucson: University of Arizona Press), 315.

‡ Morbidelli, A., Levison, H. F., Gomes, R. 2008. The Dynamical Structure of the Kuiper Belt and Its Primordial Origin. In *The Solar System Beyond Neptune,* eds. M. A. Barucci, H. Boehnhardt, D. P. Cruikshank, & A. Morbidelli (Tucson: University of Arizona Press), 275.

Brasser, R., Duncan, M. J., Levison, H. F. 2007. Embedded star clusters and the formation of the Oort cloud. II. The effect of the primordial solar nebula. *Icarus* **191**, 413.

Noll, K. S., Grundy, W. M., Stephens, D. C., Levison, H. F., Kern, S. D. 2008. 'Evidence for two populations of classical transneptunian objects: The strong inclination dependence of classical binaries'. *Icarus* **194**, 758.

Grundy, W. M., Stansberry, J. A., Noll, K. S., Stephens, D. C., Trilling, D. E., Kern, S. D., Spencer, J. R., Cruikshank, D. P., Levison, H. F. 2007. The orbit, mass, size, albedo, and density of (65489) Ceto/Phorcys: A tidally-evolved binary Centaur. *Icarus* **191**, 286.

Morbidelli, A., Tsiganis, K., Crida, A., Levison, H. F., Gomes, R. 2007. 'Dynamics of the Giant Planets of the Solar System in the Gaseous Protoplanetary Disk and Their Relationship to the Current Orbital Architecture.' *Astronomical Journal* **134**, 1790.

Bottke, W. F., Levison, H. F., Nesvorný, D., Dones, L. 2007. 'Can planetesimals left over from terrestrial planet formation produce the lunar Late Heavy Bombardment?.' *Icarus* **190**, 203.

Wittenmyer, R. A., Endl, M., Cochran, W. D., Levison, H. F. 2007. 'Dynamical and Observational Constraints on Additional Planets in Highly Eccentric Planetary Systems.' *Astronomical Journal* **134**, 1276.

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‡Levison, H.F., & Dones, L. 2006. 'Comet Populations and Cometary Dynamics.' In *The Encyclopedia of the Solar System,Second Edition,* eds. P.R. Weissman, L.A. McFadden, & T. Johnson (New York: Academic Press), 575.

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