Issue No. 12 *July 2000*

DISTANT EKOs

The Kuiper Belt Electronic Newsletter

Edited by: Joel Wm. Parker

ekonews@boulder.swri.edu www.boulder.swri.edu/ekonews

CONTENTS

NEWS & ANNOUNCEMENTS

In the report "Astronomy and Astrophysics in the New Millennium", one point of interest to Kuiper belt researchers is the discussion and endorsement of the LSST (the Large-Aperture Synoptic Survey Telescope). On pages 69–70 of the report, they recommend construction of "a 6.5-meter class very wide field (∼3 deg) telescope that will produce a deep (∼24th magnitude in a single optical band) digital map of the visible sky every week." The report mentions discovering and tracking TNOs among its programs, and one of its goals would be to study the origin and fates of comets and asteroids, and their relation to the building blocks from which planets are formed.
The report is online at: `http://books.nap.edu/books/0309070317/html/`

. . . . . .

There were 13 new TNO discoveries announced since the previous issue of the *Distant EKOs* Newsletter:

1999 CD158, 2000 CM114, 2000 CN114, 2000 CO114, 2000 CP114, 2000 CQ114,
2000 EB173, 2000 GN171, 2000 JF81, 2000 JG81, 2000 JH81, 2000 KK4, 2000 KL4;

3 new Centaur/SDO discoveries:

1999 CC158, 1999 DE9, 2000 EE153;

and 3 reclassified objects:

1996 GQ21 (TNO → SDO), 1999 RE215 (SDO → TNO), 2000 FE8 (TNO → SDO)

Current number of TNOs: 282 (and Pluto & Charon)
Current number of Centaurs/SDOs: 46

PAPERS ACCEPTED TO JOURNALS

Orbital Migration of Neptune and Orbital Distribution of Trans-Neptunian Objects

Shigeru Ida[1,2], Geoffrey Bryden[1], D.N.C. Lin[1], and Hidekazu Tanaka[2]

[1] UCO/Lick Observatory, University of California, Santa Cruz, CA 95064, USA

[2] Department of Earth and Planetary Sciences, Tokyo Institute of Technology, Meguro-ku, Tokyo 152-8551, Japan

A large number of trans-Neptunian objects are found to have orbits which are commensurate with the 3:2 mean-motion resonance of Neptune's orbit. These objects were probably captured into this resonant configuration when proto-Neptune migrated outwards from its cradle. Up to now, only a few objects have been found at Neptune's 2:1 resonance (which is also a strong mean-motion resonance). This observed distribution of objects provides a strong constraint on the migration time scale and mechanism. With a series of numerical simulations, we show that Neptune would indeed trap objects onto its 3:2 resonance if it were to migrate outward over a time scale $\gtrsim 10^6$ y. But in order to avoid the concurrent capture of objects onto its 2:1 resonance, Neptune's migration time scale must be $\lesssim 10^7$ y. Thus, the resonant capture process is likely to have occurred during the epoch of protoplanetary formation. We examine two potential mechanisms which are both compatible with the constraint set by the orbital distribution of trans-Neptunian objects. 1) In the cold outer regions of the gaseous solar nebula, proto-Neptune's tidal perturbation may have led to the formation of a gap near its orbit, the termination of its gas accretion, and the migration of its orbit along with the viscous expansion of the solar nebula on the time scale of $\sim 10^{6-7}$ y. This scenario is appealing because it can also naturally account for the limited amount of gas in Neptune's envelope. For self-consistency, we show that it is possible for proto-Neptune to acquire its core and envelope mass within the characteristic persistence time scale of protostellar disks ($\sim 10^{6-7}$ y) with an inferred solid material/gas surface density comparable to/less than those of the minimum-mass nebula respectively. 2) During its initial buildup, proto-Neptune's core not only collided and coagulated with residual planetesimals but also underwent close scatterings with large-angle deflection. We demonstrate with numerical simulations that such a process may lead to the expansion of its orbit over a few 10^6 y. The asymmetrical planetesimal distribution which drives this migration is self-sustained by the planetesimal scatterings and the migration. In other words, the migration occurs without help of other giant planets, unlike the migration models of other authors (e.g., Fernandez & Ip 1984, 1996; Hahn and Malhotra 1999) which rely on planetesimal depletion due to ejection by the strong gravitational effects of proto-Jupiter and proto-Saturn. The main advantages of this alternative scenario are that 1) it provides a fresh replenishment of residual planetesimals into the feeding zone such that proto-Neptune may acquire a core more massive than the isolation mass within $\sim 10^7$ y and 2) resonant trapping may lead to a natural termination of both proto-Neptune's planetesimal accretion and its orbital migration, determining its present core mass and position in a self-consistent manner.

Published in: The Astrophysical Journal, 534, 428 (2000 May)

The electronic article is available on the web at

`http://www.journals.uchicago.edu/ApJ/journal/issues/ApJ/v534n1/39765/39765.html`

Detection of CO and Ethane in Comet 21P/Giacobini-Zinner: Evidence for Variable Chemistry in the Outer Solar Nebula

M.J. Mumma[1], M.A. DiSanti[1,2], N. Dello Russo[1,2], K. Magee-Sauer[3], and T. W. Rettig[4]

[1] Laboratory for Extraterrestrial Physics, NASA Goddard Space Flight Center, Greenbelt, MD 20771, USA

[2] Department of Physics, Catholic University of America, Washington, DC 20064, USA

[3] Department of Chemistry and Physics, Rowan University, Glassboro, NJ 08028, USA

[4] Department of Physics and Astronomy, University of Notre Dame, Notre Dame, IN 4655, USA

Ethane and carbon monoxide were detected in a short-period comet of probable Kuiper belt origin. Ethane is substantially less abundant compared with Hyakutake and Hale-Bopp, two comets from the giant - planet's region of the solar nebula, suggesting a heliocentric gradient in ethane in pre-cometary ices. It is argued that processing by X-rays from the young sun may be responsible.

Published in: The Astrophysical Journal, 531, L155 (2000 March 10)
For preprints, contact mmumma@kuiper.gsfc.nasa.gov
or on the web at:
http://www.journals.uchicago.edu/ApJ/journal/issues/ApJL/v531n2/995453/995453.html

. . . . . .

Dust in the 55 Cancri Planetary System

Ray Jayawardhana[1], Wayne S. Holland[2], Jane S. Greaves[2], William R. F. Dent[3], Geoffrey W. Marcy[4], Lee W. Hartmann[1], Giovanni G. Fazio[1]

[1] Harvard-Smithsonian Center for Astrophysics, 60 Garden St., Cambridge, MA 02138, USA

[2] Joint Astronomy Centre, 660 N. A'ohoku Place, University Park, Hilo, HI 96720, USA

[3] UK Astronomy Technology Centre, Royal Observatory, Blackford Hill, Edinburgh EH9 3HJ, United Kingdom

[4] Department of Astronomy, University of California, Berkeley, CA 94720, USA

The presence of debris disks around $\sim$ 1-Gyr-old main sequence stars suggests that an appreciable amount of dust may persist even in mature planetary systems. Here we report the detection of dust emission from 55 Cancri, a star with one, or possibly two, planetary companions detected through radial velocity measurements. Our observations at 850μm and 450μm imply a dust mass of 0.0008-0.005 Earth masses, somewhat higher than that in the the Kuiper Belt of our solar system. The estimated temperature of the dust grains and a simple model fit both indicate a central disk hole of at least 10 AU in radius. Thus, the region where the planets are detected is likely to be significantly depleted of dust. Our results suggest that far-infrared and sub-millimeter observations are powerful tools for probing the outer regions of extrasolar planetary systems.

Published in: Astrophysical Journal 536, 425 (2000 June 10)
For reprints, contact rayjay@cfa.harvard.edu
or on the web at http://arxiv.org/abs/astro-ph/0001275

PAPERS RECENTLY SUBMITTED TO JOURNALS

Planetary Migration and Plutinos Orbital Inclinations

R.S. Gomes[1]

[1] Observatório Nacional, Rua General José Cristino, 77, 20921-400, Rio de Janeiro, RJ, Brazil

Submitted to: The Astronomical Journal

For preprints, contact rodney@on.br

CONFERENCE CONTRIBUTIONS

(see also the table of contents for "Protostars and Planets IV" later in this issue)

Recovery Observations of Trans-Neptunian Objects

T. Grav[1], **K. Aksnes**[1], **N. Haug**[1] **and M. Holman**[2]

[1] Institute of Theoretical Astrophysics, University in Oslo, Postbox 1029 Blindern, Oslo, Norway

[2] Harvard-Smithsonian Center for Astrophysics, 60 Garden Street, Cambridge, MA 02138, USA

To appear in: "NOT in the 2000s" conference proceedings

For preprints, contact tommy.grav@astro.uio.no

THESES

Circumstellar Dust: From Protostars to Planetary Systems

Ray Jayawardhana[1,2]

[1] Harvard-Smithsonian Center for Astrophysics, 60 Garden Street, MS-10, Cambridge, MA 02138, USA

[2] As of 1 Aug 2000: Department of Astronomy, Campbell Hall, University of California, Berkeley, CA 94720, USA

A combination of theoretical work and observational discoveries over the past three decades has led to significant advances in our understanding of the star and planet formation process. However, many important questions remain to be addressed, especially regarding the earliest phases of protostellar collapse and the transformation of circumstellar disks into planetary systems. In this thesis, I have undertaken a theoretical study of "Class 0" protostars and an observational investigation of the evolution of protoplanetary disks, diversity of planetary debris systems, and the kinship between dusty remnants and planets, using a new generation of infrared and sub-millimeter instruments.

I present radiative transfer calculations of infalling envelopes surrounding Class 0 sources, compare them to the observed spectral energy distributions and radial intensity profiles, and derive mass infall rates. The rapid infall, probably inevitable given their dense environments, and the relatively flat inferred density distribution, perhaps due to contributions from external cloud material, lead us to suggest that many Class 0 sources could be the protostars of dense regions.

It has been suggested that circumstellar disks evolve from massive, optically thick, actively accreting structures to low-mass, optically thin, passive remnants in about 10 Myr. That transition may mark the assembly of grains into planetesimals, or clearing of the disk by planets. I present mid-infrared observations of the TW Hydrae Association, a recently-identified nearby group of 10-Myr-old stars. The results suggest rapid evolution of inner disks as does our discovery of a spatially-resolved disk with a central cavity around the young A star HR 4796A. I also present the results of mid-infrared imaging of 11 other Vega-like stars, derive global properties of the dust disks, place constraints on their sizes, and discuss several interesting cases in detail. Finally, I report the detection of dust emission from a possible Kuiper Belt around 55 Cancri, a star with known planetary companion(s).

Ph.D dissertation directed by: Giovanni Fazio and Lee Hartmann
Ph.D degree awarded: May 2000 from Harvard University

For preprints, contact `rayjay@cfa.harvard.edu`
`rayjay@astro.berkeley.edu` (after 1 Aug 2000)

. . . . . .

Light Scattering and Evolution of Protoplanetary Disks and Planetary Rings

Henry Throop[1]

[1] Laboratory for Atmospheric & Space Physics, University of Colorado, Boulder, CO 80309-0392, USA

This thesis examines observations and modeling of young circumstellar disks in the Orion nebula. Three separate arguments suggest that the disks are dominated by large particles, and we are witnessing earliest stages of planetary formation.

I) I used a Monte Carlo nine-parameter 3D disk model to fit Hubble Space Telescope observations in eleven bands from 0.2 – 1.9 μm. The best-fit models are consistent with extinction caused by large particles, $r > \lambda$ in the outer disk edge. II) Interferometric observations at 1.3 mm reveal no measurable flux from the disks, implying that the optical depth is low and thus particles have grown to $r > 1$ mm. III) Numerical models of particle growth within a photoevaporative environment indicate that grain growth happens rapidly and predicts particle sizes similar to those constrained observationally. The model includes a) grain growth in a turbulent disk, b) ice loss by photosputtering, and c) gas and dust loss by entrainment of small particles in a photoevaporative flow. The disks are photoevaporated on timescales of 10^{4-6} yr by O stars in the Trapezium region.

The numerical model indicates that formation of Jovian planets within the Orion region and other OB associations may be difficult; however, formation of terrestrial planets is not affected. I reproduce the observed sharp edge termination in the Orion disks. The existence of Jovian planets within our solar system suggests that our disk is not sharply terminated, and the Edgeworth-Kuiper belt may extend significantly beyond that presently detected.

I apply a similar numerical model to evolution of Saturn's G ring, based on spectroscopic observations at the 1995-96 ring plane crossing, coupled with a light scattering model for realistic, processed small particles. Best-fit solutions indicate that the ring was formed by catastrophic disruption of a satellite $10^7 - 10^8$ years ago and is sustained in steady-state by an unseen population of km-sized parent bodies.

Dissertation directed by: L.W. Esposito and J. Bally
Ph.D. awarded: May 2000 from the University of Colorado, Boulder

For preprints, contact `throop@broccoli.colorado.edu`
or on the web at `http://bogart.Colorado.EDU/~throop/research.html#latest_results`

BOOKS

Protostars and Planets IV

Edited by Vince Mannings, Alan P. Boss, & Sara S. Russell

CONTENTS

- *Spectroscopy of Inner Protoplanetary Disks and the Star-Disk Interface*
  J.R. Najita, S. Edwards, G. Basri, and J. Carr
- *High-resolution Optical and Near-infrared Imaging of Young Circumstellar Disks*
  M.J. McCaughrean, K.R. Stapelfeldt, and L.M. Close
- *Subarcsecond Millimeter and Submillimeter Observations of Circumstellar Disks*
  D.J. Wilner and O.P. Lay
- *Dust Properties and Assembly of Large Particles in Protoplanetary Disks*
  S.V.W. Beckwith, T. Henning, and Y. Nakagawa
- *Properties and Evolution of Disks Around Pre-main-sequence Stars of Intermediate Mass*
  A. Natta, V.P. Grinin, and V. Mannings
- *Transport Processes in Protostellar Disks*
  J.M. Stone, C.F. Gammie, S.A. Balbus, and J.F. Hawley
- *Infalling Planetesimals in Pre-main-sequence Stellar Systems*
  C.A. Grady, M.L. Sitko, R.W. Russell, D.K. Lynch, M.S. Hanner, M.R. Pérez, K.S. Bjorkman, and D. de Winter
- *Planetary Material Around Main-sequence Stars*
  A.-M. Lagrange, D.E. Backman, and P. Artymowicz

PART III—Young Binaries

- *Multiple Fragmentation of Protostars*
  P. Bodenheimer, A. Burkert, R.I. Klein, and A.P. Boss
- *Young Binary Stars and Associated Disks*
  R.D. Mathieu, A.M. Ghez, E.L.N. Jensen, and M. Simon
- *Interactions of Young Binaries With Disks*
  S.H. Lubow and P. Artymowicz

PART IV—Jets and Outflows

- *Disk Winds and the Accretion-outflow Connection*
  A. Königl and R.E. Pudritz
- *X-Winds: Theory and Observations*
  F.H. Shu, J.R. Najita, H. Shang, and Z.-Y. Li
- *Collimation and Propagation of Stellar Jets*
  J. Eislöffel, R. Mundt, T.P. Ray, and L.F. Rodríguez
- *Shock Structures and Momentum Transfer in Herbig-Haro Jets*
  P. Hartigan, J. Bally, B. Reipurth, and J.A. Morse
- *Molecular Outflows From Young Stellar Objects*
  J.S. Richer, D.S. Shepherd, S. Cabrit, R. Bachiller, and E. Churchwell

Part V—Early Solar System and Planet Formation

- *The FU Orionis Phenomenon and Solar Nebula Material*
  K.R. Bell, P.M. Cassen, J.T. Wasson, and D.S. Woolum
- *Formation of Chondrules and Cais: Theory vs. Observation*
  R.H. Jones, T. Lee, H.C. Connolly, Jr., S.G. Love, and H. Shang
- *Extinct Radionuclides and the Origin of the Solar System*
  J.N. Goswami and H.A.T. Vanhala
- *Timescales of Accretion and Differentiation in the Early Solar System: The Meteoritic Evidence*
  M. Wadhwa and S.S. Russell

- *Meteoritical and Astrophysical Constraints on the Oxidation State of The Solar Nebula*
  A.N. Krot, B. Fegley, Jr., K. Lodders, and H. Palme
- *The Outer Solar System: Chemical Constraints at Low Temperatures on Planet Formation*
  J.I. Lunine, T.C. Owen, and R.H. Brown
- *Giant Planet Formation*
  G. Wuchterl, T. Guillot, and J.J. Lissauer
- *Orbital Evolution and Planet-Star Tidal Interaction*
  D.N.C. Lin, J.C.B. Papaloizou, C. Terquem, G. Bryden, and S. Ida
- *Disk-Planet Interactions and the Formation of Planetary Systems*
  W.R. Ward and J.M. Hahn

Part VI—Comets and the Kuiper Belt

- *Comets: A Link Between Interstellar and Nebular Chemistry*
  W.M. Irvine, F.P. Schloerb, J. Crovisier, B. Fegley, Jr., and M.J. Mumma
- *Physical Nature of the Kuiper Belt*
  D.C. Jewitt and J.X. Luu
- *Dynamics of the Kuiper Belt*
  R. Malhotra, M.J. Duncan, and H.F. Levison
- *Formation and Collisional Evolution of the Edgeworth-Kuiper Belt*
  P. Farinella, D.R. Davis, and S.A. Stern

Part VII—Extrasolar Planets and Brown Dwarfs

- *Extrasolar Planets Around Main-sequence Stars*
  G.W. Marcy, W.D. Cochran, and M. Mayor
- *Brown Dwarfs*
  B.R. Oppenheimer, S.R. Kulkarni, and J.R. Stauffer
- *New Ideas in the Theory of Extrasolar Giant Planets and Brown Dwarfs*
  A. Burrows, W.B. Hubbard, J.I. Lunine, M.S. Marley, and D. Saumon

Part VIII—Initial Conditions For Astrobiology

- *Planetary Habitability and the Origins of Life*
  C.F. Chyba, D.P. Whitmire, and R. Reynolds

Protostars and Planets IV is now on sale. The purchase price is $95.00. Please order directly from the University of Arizona Press on:

`http://www.uapress.arizona.edu/books/BID1316.htm`

Alternatively, the book can be purchased through:

`http://www.amazon.com` and `http://www.bn.com`

CONFERENCE INFORMATION

32nd Meeting of the AAS Division for Planetary Sciences

2000 October 23-27
Pasadena, California, USA

`http://www.aas.org/dps2000/`

You are cordially invited to attend the 32nd annual meeting of the Division for Planetary Sciences of the American Astronomical Society, on 23-27 October 2000 in Pasadena, California. The meeting will be held at the Pasadena Convention Center, 300 E. Green Street, in the heart of Pasadena. The meeting is hosted by the Jet Propulsion Laboratory. The Program Chair for the meeting is Paul Weissman. The Local Organizing Co-Chairs are Bill Smythe and Rosaly Lopes.

The program for the DPS 2000 meeting will be a fairly standard one, with a mix of invited and contributed talks in double sessions, special sessions on Galileo at Io and NEAR at Eros, and posters. Posters will be prominently displayed and will be up all week from noon, Monday, to afternoon Friday. Authors are encouraged to contribute posters to conserve the limited number of oral time slots. Based on the results of the membership poll taken last November, all mission description and instrument description papers will be assigned to poster sessions. Posters provide a much better venue for displaying the visual and often detailed information that comes with this type of abstract.

For more information (deadlines, registration, travel) visit the website at:

`http://www.aas.org/dps2000/`

The *Distant EKOs* Newsletter is dedicated to provide researchers with easy and rapid access to current work regarding the Kuiper belt (observational and theoretical studies), directly related objects (e.g., Pluto, Centaurs), and other areas of study when explicitly applied to the Kuiper belt.

We accept submissions for the following sections:
⋆ Abstracts of accepted papers
⋆ Titles of submitted (but not yet accepted) papers and conference articles
⋆ Thesis abstracts
⋆ Short articles, announcements, or editorials
⋆ Status reports of on-going programs
⋆ Requests for collaboration or observing coordination
⋆ Table of contents/outlines of books
⋆ Announcements for conferences
⋆ Job advertisements
⋆ General news items deemed of interest to the Kuiper belt community

A LaTeX template for submissions is appended to each issue of the newsletter, and is sent out regularly to the e-mail distribution list. Please use that template, and send your submission to:

`ekonews@boulder.swri.edu`

The *Distant EKOs* Newsletter is available on the World Wide Web at:

`http://www.boulder.swri.edu/ekonews`

Recent and back issues of the Newsletter are archived there in various formats. The web pages also contain other related information and links.

Distant EKOs is not a refereed publication, but is a tool for furthering communication among people interested in Kuiper belt research. Publication or listing of an article in the Newsletter or the web page does not constitute an endorsement of the article's results or imply validity of its contents. When referencing an article, please reference the original source; *Distant EKOs* is not a substitute for peer-reviewed journals.

Moving ... ??

If you move or your e-mail address changes, please send the editor your new address. If the Newsletter bounces back from an address for three consecutive issues, the address will be deleted from the mailing list. All address changes, submissions, and other correspondence should be sent to:

`ekonews@boulder.swri.edu`