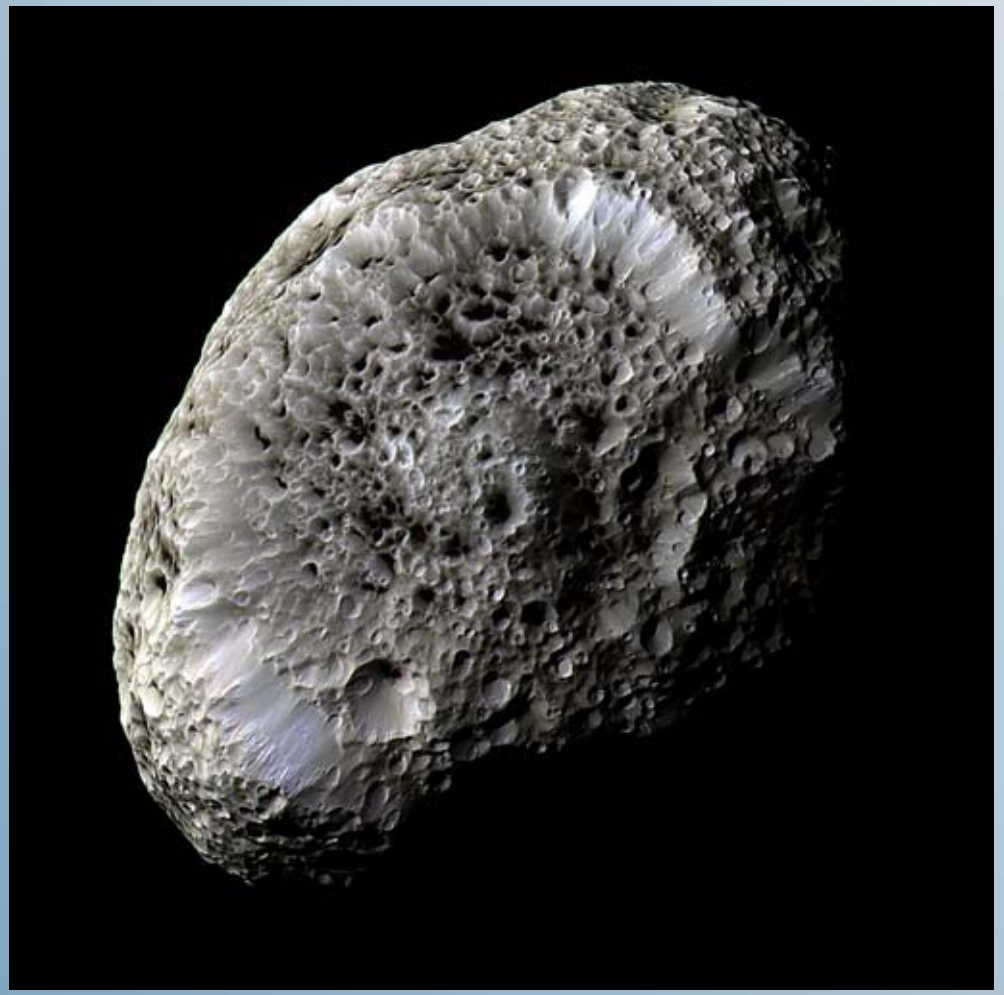


Small Bodies and Dust and SolSys Form. Working Group

Amara.L. Graps

INAF-IFSI , Rome, Italy

August 21-23, 2006, Helsinki

'Ordered' Science Cases

Last November 2005 (Northeim). Results from systems analysis: (most broad coverage of targets and most involved methods of study)

ISSI

HOW →

COMETS

1. How can we best optimise from observations, numerical experiments, laboratory simulations, further analysis of past mission data the science return of Rosetta?

'Added on' in April (due to a preponderance of participants working in comets:

7. What are the physical/chemical processes leading to distant activity, outbursts, splitting and disruption of cometary nuclei?

(Schmidt's)
Solar wind-comet surface interaction
-Surface material composition

WHAT →

3. What are the relative contributions of asteroidal dust, cometary dust, meteor streams, interstellar dust and circumplanetary dust to the structure of the zodiacal dust cloud as a function of heliocentric distance, latitude (and time)?

WHAT →

6. What are the connections between TNOs, centaurs, trojans, comets and icy satellites and **what is the dynamical and morphological structure of the Kuiper belt**?

For Our Science Cases

Comets Science Cases - Possible collusion/duplication of efforts with ISSI Workshop and Rosetta SWT. Proposal: At the moment, it might be best to:

- Follow the progress in the ISSI workshops and Team Meetings
- Follow the progress in the Rosetta SWTs

From K. Altwegg, 10May06:

"The purpose of this {ISSI] working group is: "The Working Group (WG) shall identify and initiate investigation of hot scientific topics with data from Giotto and other spacecraft and remote sensing and thus prepare for coordinated composition investigations and raise interest for and attractiveness of the field within the next generation. Furthermore complementary laboratory measurements that are instrumental for quantitative Rosetta analyses shall be identified and initiated." Currently we are preparing an ISSI workshop on "Origin and Early Evolution of Comet Nuclei" which will be held in October this year at ISSI. Apart from this workshop the working group has started an archive on compositional data from comets (in situ and remote sensing) and on compiling a document which will specify the capabilities of the Rosetta instruments with regards to composition. It will also contain suggestions for common calibration campaigns and common science goals of all sensors which will analyze composition of the volatiles and the dust of C-G. We have also started a list of laboratory measurements to be done prior to the Rosetta rendezvous with C-G. I think that one of the results of this working group will also be a recommendation to ISSI which role ISSI should play in the preparatory work for Rosetta."

From ISSI Web site:

17-20. October ISSI Workshop: Origin and Early Evolution of Comet Nuclei - Workshop

7. August Working Group on "Composition of Comets "

For Our Science Cases

1. What are the relative contributions of asteroidal dust, cometary dust, meteor streams, interstellar dust and circumplanetary dust to the structure of the zodiacal dust cloud as a function of heliocentric distance, latitude (and time)?

2. What is the dynamical and morphological structure of the Kuiper belt?

I need Input from the Community.

Steps:

1) Comprehensive Email List.
Note: Europlanet is about *Networking*. A good email list for the Small Bodies and Dust and SolSys Form. Working Group is the first essential step.
Especially necessary when persons representing that discipline are not physically present in the meetings.

2) Engage Experts.

For Our Science Cases - Email List

1) Comprehensive Email List.

Selected researchers who presented work at ACM 2005, ACM 2002, Meteoroids 2001, GUCS, last 5 years.
(Solar System Formation is still not well-represented, however, and number of Rosetta Team members can be increased).

Result: We have 146 People. Excel Spreadsheet(s) versions sorted by name, institute.

Gives: last_name, first_name, email, institute, node, topic

Sample:

Kathrin	Altwegg	kathrin.altwegg@phim.unibe .ch,	Physikalisches Institut, Universität Bern	?	comets
Marek	Banaszkiewicz,	marekb@cbk.waw.pl,	Space Research Centre	38	dust
Cesare	Barbieri	barbieri@oapd.inaf.it,	Dipartimento di Astronomia, Universit`a di Padova	20	exospheres, Mercury, small bodies
Antonella	Barucci	antonella.barucci@obspm.fr,	Observatoire de Paris	2	asteroids
Johannes	Benkhoff	Johannes.Benkhoff@dlr.de,	DLR,	?	comets
Jérôme	Berthier	berthier@imcce.fr,	Institut de mecanique celeste	2.3	asteroids

BUT (European Institutes of Present Email Experts) DO NOT EQUAL (Europlanet Nodes) !

For Our Science Cases - Email List

1) (Continued) Not Europlanet Nodes. Suggest to add for FP7:

DLR
University of Oslo Institute of Theoretical Astrophysics
University of Jena
Physikalisches Institut, Universität Bern
Technical University Braunschweig
University of Kent at Canterbury
Leiden University
Queen Mary, University of London
Queen's University Belfast
Università di Pisa
University of Helsinki Observatory
Observatoire de Besançon
Observatoire de Marseilles (?)
Comenius University Bratislava
Vatican Observatory

For Our Science Cases - Engaging Experts

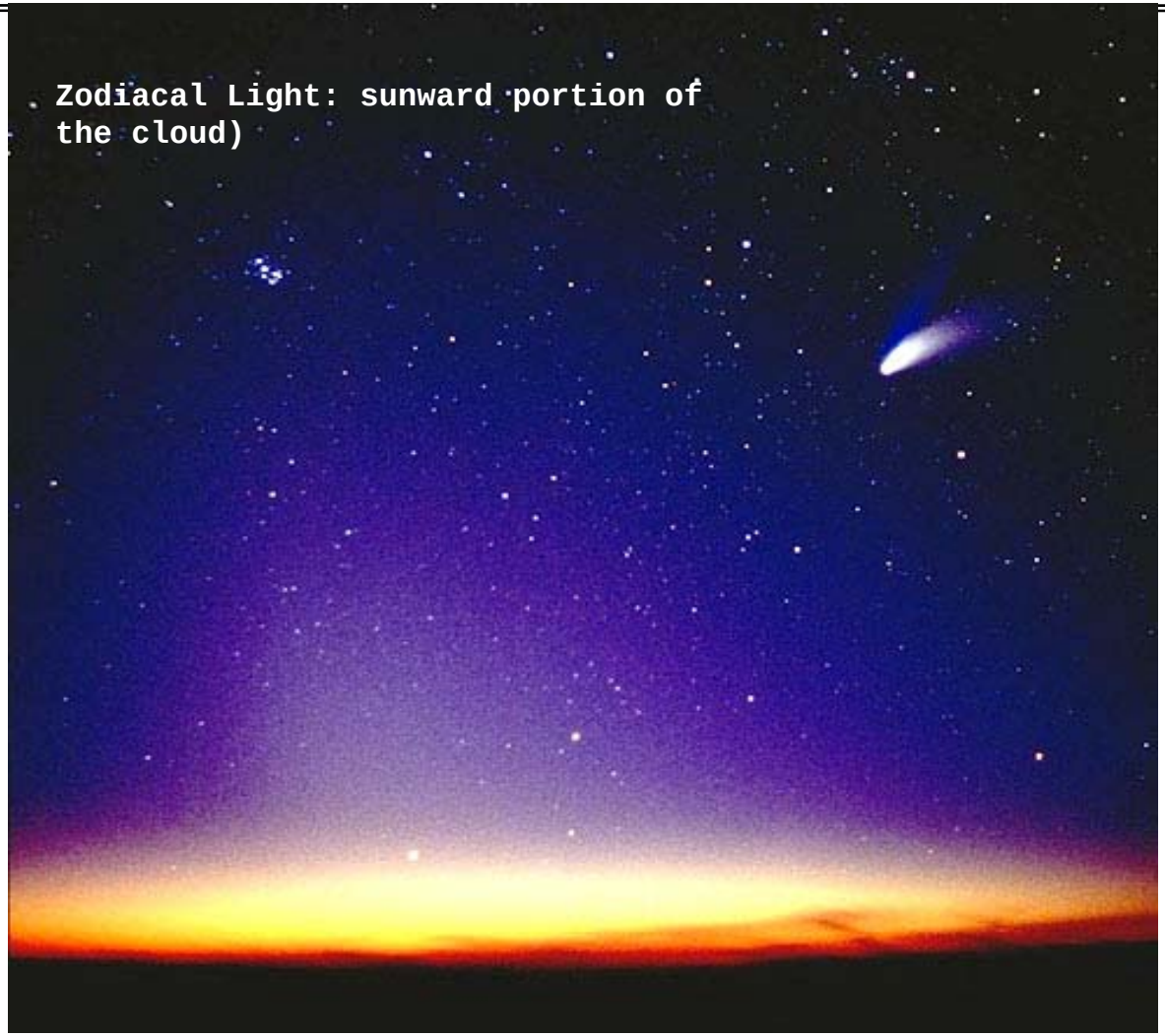
2) Engaging Experts.

Still in progress. Free time = 0 :-(

Contribution to Zodiacal Cloud?

1. What are the relative contributions of asteroidal dust, cometary dust, meteor streams, interstellar dust and circumplanetary dust to the structure of the zodiacal dust cloud as a function of heliocentric distance, latitude (and time)?

A debate occurred on this topic at the "Dust in the Solar System and Other Planetary Systems" September 2005 Meeting.
-Question still relevant.
-Further addressed in Proceedings book: (Krueger and Graps, ed. 2006 (Fall)



Marco Fulle from Stromboli 1997 Hale Bopp & Wedge of Cosmic Dust

"Découverte de la lumiere celeste qui paroist dan le zodiaque" (Cassini 1693)

Contribution to Zodiacal Cloud?

2) Needed Data Sets (needed for spatial distribution, number density, size, shape, structure, and composition)

• Mission: In-situ Dust and Comet Flybys and Future Mission (Cosmic DUNE)
• Ground: Meteor surveys, Arctic/Antarctic Ice, and Stratospheric, photometry
• Laboratory: Dust (comet: Stardust), IDP Database (Houston), Polarization Studies (Levasseur-Regourd, Gustafson
• not usually considered, e.g. MER

And Needed Models (for the temporal evolution and location in space):

• Empirical: Update of the Grün interplanetary complex (Dikarev), Kelsall
• Theoretical: Dynamical Evolution (Krivov, Landgraf, Liou, ...)

• Presently, the ESA Darwin mission is producing an open-source toolkit for exo-system modeling, where the zodiacal cloud models are based on [Kelsall et al., ApJ, 508:44-73, 1998]. Existing software: “Zodipic”

3) How do Scientists Select the Needed Data?

In-situ: some from the Web
Heidelberg: Galileo, Cassini
ESA (Earth vicinity): GORID, Proba

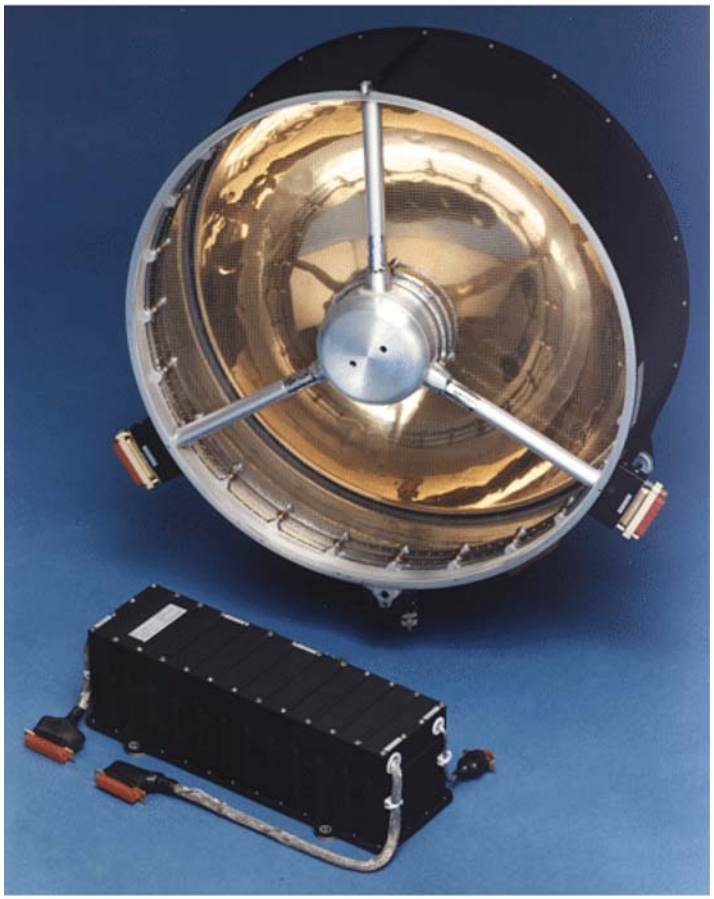
Meteor Surveys: from the Individual Scientists

Antarctic/Arctic Ice, Stratospheric: Houston

Laboratory data: from the Individual Scientists

Databases: In-situ Dust Data

Galileo Dust Detector System

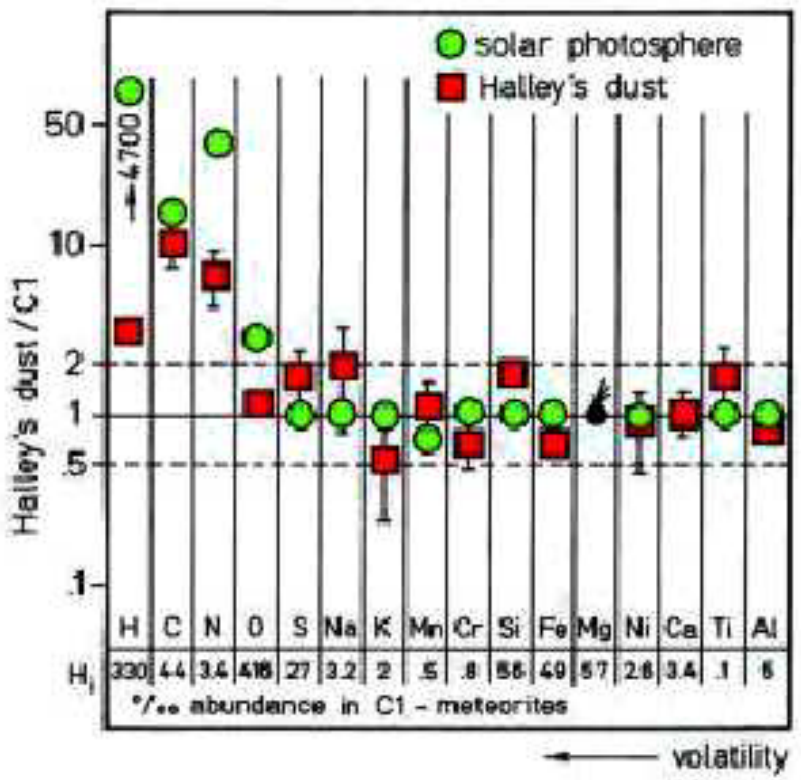


(r.i.p. 21.9.03)

Databases: Galileo (*), GORID (*), Pioneer 10/11 (*), HEOS-2 (?), Helios (?), Ulysses, Cassini, , Rosetta, ...

(*) Mission ended. Data archived.

Comet Halley Dust Elemental Abundance Compared to Solar



Databases: Giotto, VeGa, Stardust, Deep Impact, ...

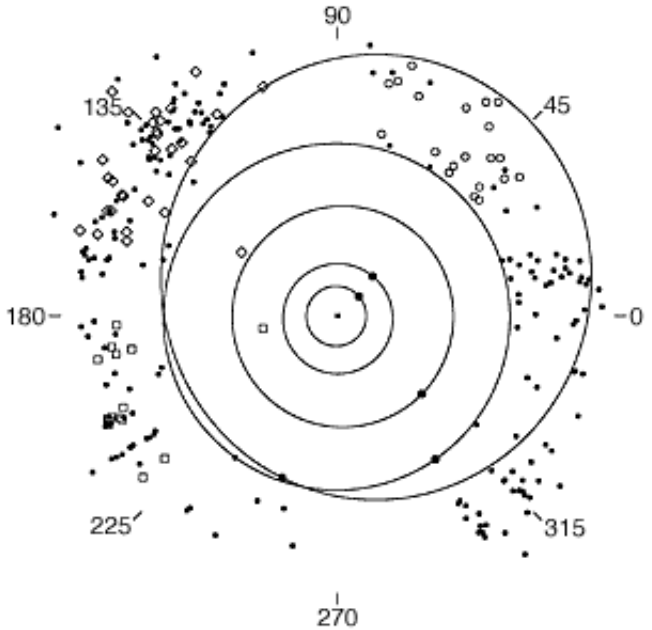
The average abundance of elements (with increasing refractivity from left to right in dust from comet Halley (squares) compared to element abundances in the solar photosphere (circles). All abundances are normalised to the elementary abundances of C1 chondrites. The error bars indicate the variability of the measured dust grains.

(Kissel, J. and Krueger, F.R. (1987). The organic component in dust from comet Halley as measured by the PUMA mass spectrometer onboard Vega 1. Nature 326, 755-760.)

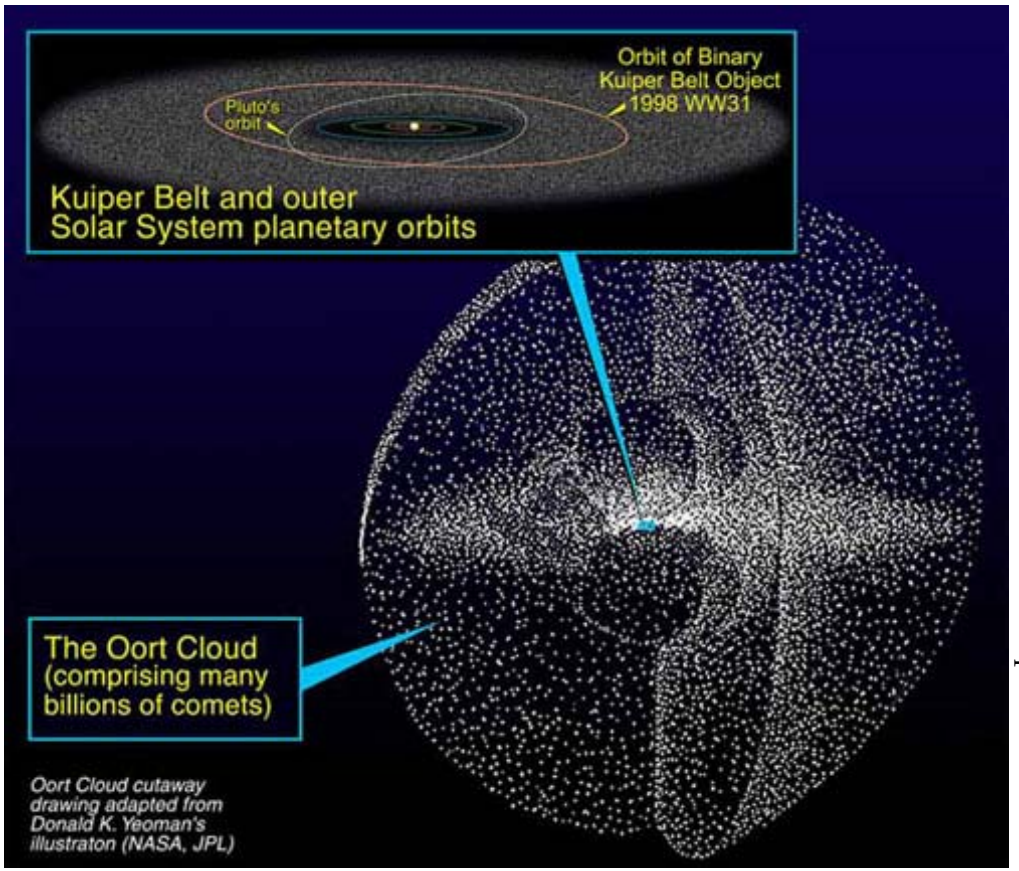
For Our Science Cases (cont.)

2. What is the dynamical and morphological structure of the Kuiper belt?
KB ~ orbit of Neptune (30 AU) to ~50 AU.

http://www.noao.edu/outreach/current/kbohilite.html



The locations in 2000 of the 150 known KBOs in relation to the outer planets' orbits.



Artist's Rendition from Wikipedia

The current distribution of known objects is likely to be strongly affected by observational bias. Most observations have so far focused on near-ecliptic objects. Even objects with high inclinations (e.g. 2004 XR190) were actually found at near ecliptic positions. In addition, most of the known KBOs are detected near their closest approaches to the Sun since they appear dimmer at greater distances.

For Our Science Cases (cont.)

Why?
More primordial than the Oort Cloud
(less perturbed orbits, ejected by Uranus and Neptune)

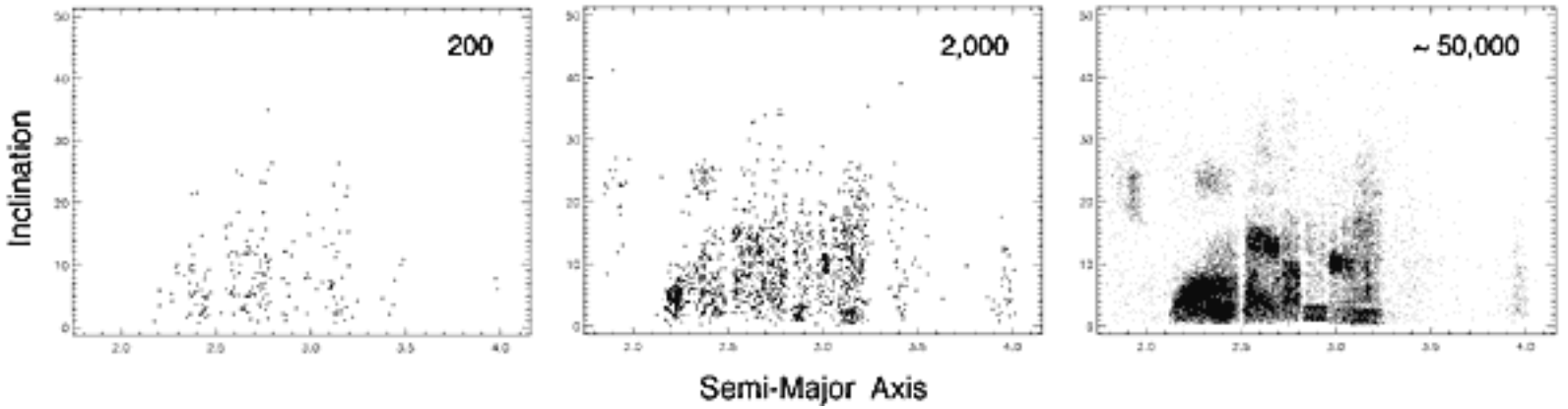
First thing to be discovered in extrasolar systems.

It is hoped that the KB is analogous to the debris disks seen around other stars, which are also probably the remnants of solar system formation.

(Note: we can see the dust from collisions around distant stars more easily than we can in our own solar system. The zodiacal cloud blocks our view.)

For Our Science Cases (cont.)

Knowledge of KBOs today = Knowledge of Asteroids in 1975



The three graphs above plot the locations of asteroid orbits when a) only 200 were known, b) 2000 were known, and c) 50,000 were known. Eccentricity (y axis) is the degree of tilt that the object's orbit has to the plane of the solar system. Semi-major axis (x axis) can be thought of as relative distance from the Sun. The greater amount of data in c shows that asteroids cluster in families within the main asteroid belt (the dark clumps) and don't cluster in other areas (the light, vertical lines). This can't be detected in the first two graphs, which have fewer objects. The areas without asteroids show places where asteroids don't have a stable resonance with Jupiter, the large nearby planet whose gravity stirs up the asteroid belt.

1 http://www.noao.edu/outreach/current/kbohilite.htm

For Our Science Cases (cont.)

> 1000 Kuiper belt objects (KBOs) have been discovered in the belt, almost all of them since 1992.

Among the largest are Pluto and Charon, but since the year 2000 other large objects that approached their size were identified. 50000 Quaoar, discovered in 2002, which is a KBO, is half the size of Pluto and is larger than Ceres.

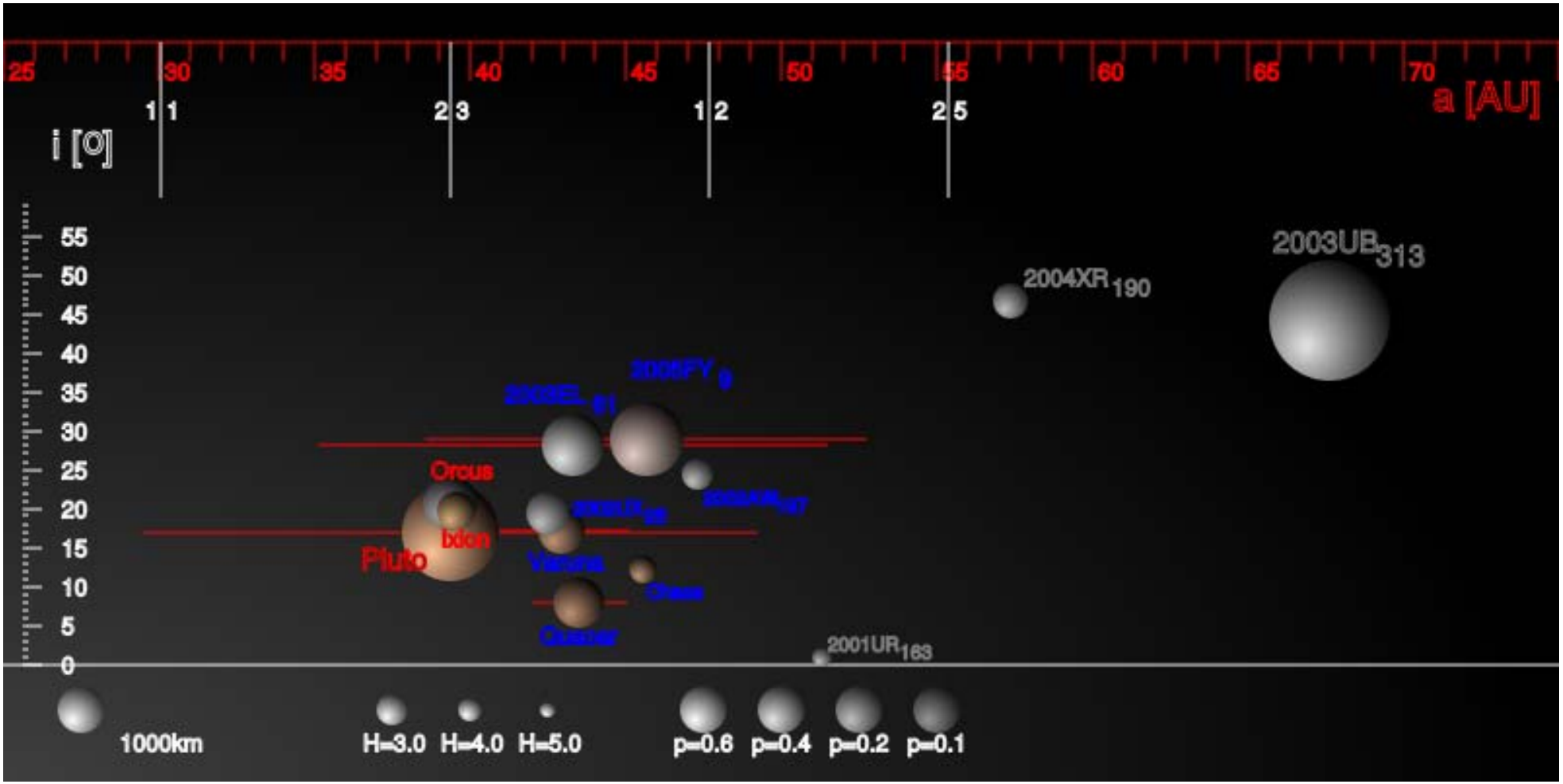
2005 FY9 (nicknamed "Easterbunny") and 2003 EL61 (nicknamed "Santa"), both announced on 29 July 2005, are larger still.

Other objects, such as 28978 Ixion (discovered in 2001) and 20000 Varuna (discovered in 2000) while smaller than Quaoar, are nonetheless quite large. Sedna, a red planetoid with a diameter roughly half-way between Pluto and Quaoar, was first sighted on November 14th 2003.

The largest recent discovery is 2003 UB313 (nicknamed "Xena").

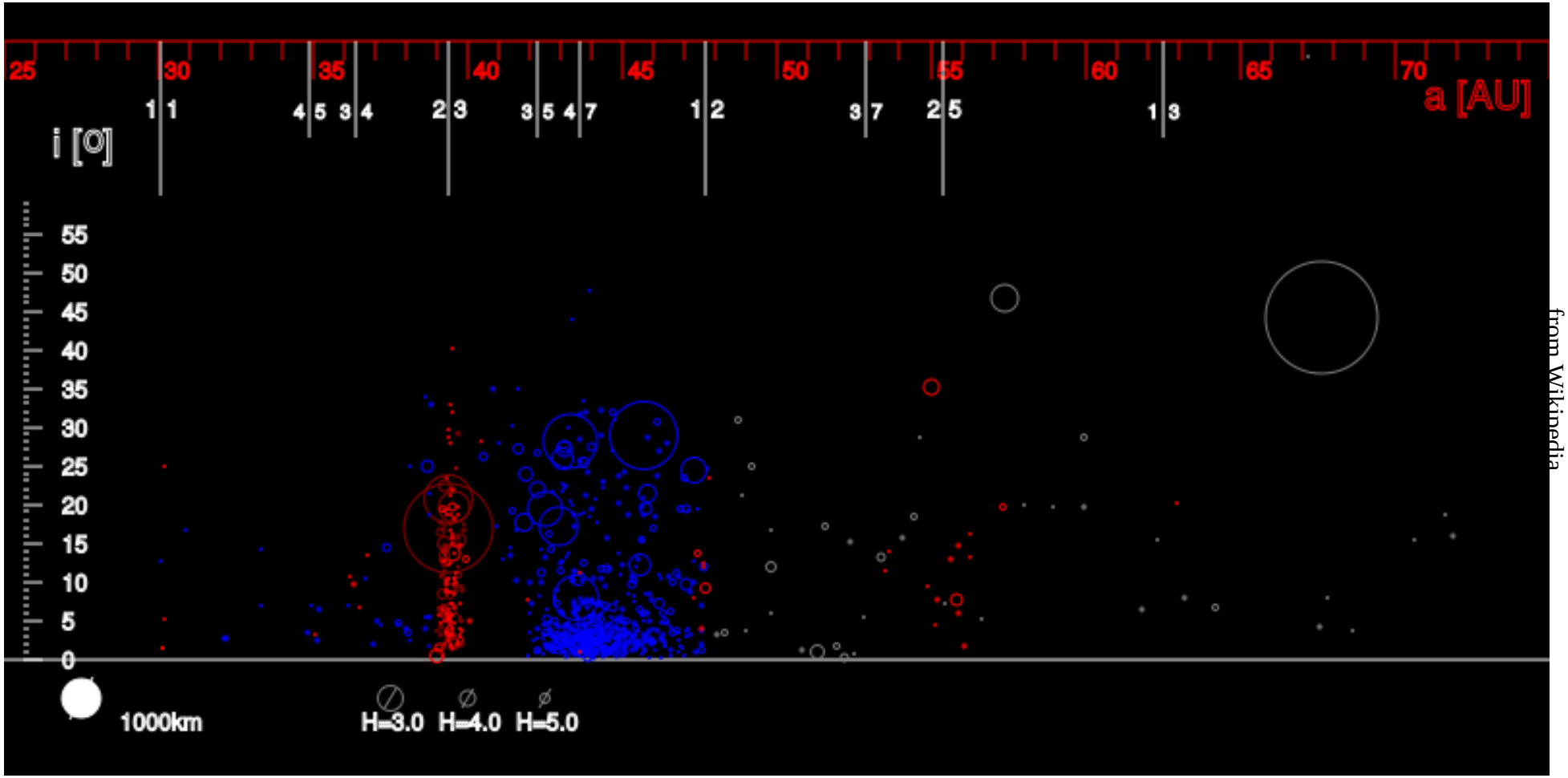
* The exact classification of these objects is unclear, since they are probably fairly different from the asteroids of the asteroid belt.

For Our Science Cases (cont.)



from Wikipedia

For Our Science Cases (cont.)



from Wikinedia

For Our Science Cases (cont.)

2) Engaging Experts.

AG is engaging experts of whom to ask questions (presently writing a list of questions to Morbidelli, for example). With Europlanet depending on the free time of scientists, this is a slow process.

For Our Science Cases (cont.)

3) Useful recent conference (no proceedings, however).

International Workshop
Trans Neptunian Objects
Dynamical and Physical properties
Catania, Italy
July 3-7 2006

For Our Science Cases (cont.)

Useful recent conference (First 1.5 Days of Talks).

Monday 3:

16:00-16:40 PROVOCATIVE INTRODUCTION (Invited) Morbidelli A.

Session: DYNAMICS

16:40-17:20 The primordial sculpting of the Kuiper belt (Invited) Levison H.F.
17:20-17:40 Coffee Break
17:40-18:00 Dynamical evolution of Kuiper Belt Del Popolo A.
18:00-18:20 The Resonant Captures of TNOs Jiang I. & Yeh Li-Chin
18:20-18:40 Dynamical Friction and Planet Scattering in the Outer Solar System Ford E. & Chiang E.
18:40-19:00 The transneptunian region architecture: a formation scenario Sofia Lykawka P. & Mukai T.

Tuesday 4:

Session: DYNAMICS continued

09:00-09:40 The Extended scattered disk: Kuiper belt or Oort cloud? (Invited) Fernandez J.
09:40-10:20 The formation of binary TNOs (Invited) Farrelly D. et al.
10:20-10:40 Capture of Irregular Moons by 3-Body Reactions Nesvorny D. et al.

11:00-11:20 TNO orbit computation: analysing the observed population Virtanen J. et al.
11:20-11:40 The orbit and atmospheric trajectory of the Orgueil meteorite from historical records Gounelle M. et al.

For Our Science Cases (cont.)

11:40-12:00 Dynamics of Centaurs Dones L. et al.
12:00-12:20 Orbit determination of Binary TNOs Hestroffer D. & Vachier F.

Session: DISCOVERIES
12:20-13:00 The big objects population (Invited) Brown M.E.
16:00-16:40 The CFHT survey: first results (Invited) Petit J.M. & Gladman B.
16:40-17:20 The census of binary TNOs (Invited) Noll K.
17:40-18:00 Discovery and Characterization of Binary KBOs with the Magellan Telescopes Kern S. & Elliot J.L.
18:00-18:20 Modelling the populations of Trans-neptunian objects Campo Bagatin A. et al.
18:20-18:40 Taiwanese-American Occultation Survey: status of the project Bianco F.
18:40-19:00 Whipple: A Space-Based Occultation Survey Lehner M.

Expertise in Building Instruments in Europe (for small bodies and dust)

SOME INSTITUTES WITH EXPERTISE IN BUILDING INSTRUMENTS WHICH ARE OF INTEREST FOR SMALL BODIES AND DUST IN EUROPE:

Near-UV, Visible, NIR imagers: Lindau; Marseilles; Orsay (IAS); DLR/Berlin
UV spectrometers: Aeronomie/France(IPSL-UPMC)
Visible spectrometry: IASF/Rome; IFSI/Rome; Observatoire de Paris-Meudon
Microwave spectrometry: Observatoire de Paris-Meudon
Dust spectrometry: Lindau
Gas spectrometry: CETP/France(IPSL); Lindau
Radar type instruments: Aeronomie/France(IPSL-UPMC); Grenoble; Lindau; Rome
Atomic force microscopy: Graz/Austria; ESTEC
Dust impact instruments: Univ. Naples; Capodimonte Obs. Naples; Heidelberg; TU Muenchen; Open Univ./UK
Plasma instruments: LPCE/Orléans
Gas chromatography: Open Univ./UK; Aeronomie/France(IPSL-UPMC); LISA/France; Lindau
Magnetometer: IC/London; Braunschweig; Orléans
Energetic particle instruments: Toulouse; Mainz; IRF/Kiruna; IFSI/Rome; CETP/France(IPSL); Lindau
Radio science: DLR/Germany; Univ. Rome

Laboratory Experiments Expertise in Europe (for small bodies and dust)

SOME INSTITUTES WITH LABORATORY EQUIPMENT:

Capodimonte Obs. Naples/Univ. of Parthenope: dust production, processing and analysis
MPIK Heidelberg, Open Univ./UK; Univ. of Kent/UK; TU Munich: Dust impact simulation
TU Braunschweig; TU Munich; Univ. Jena: Dust coagulation experiments
Aeronomie/France(IPSL-UPMC), LPCE/Orléans: light scattering exp. for dust and regoliths; dusty plasma exp.
MPE Garching: dusty plasma exp.
Leiden: interstellar dust analogues