Experience with Small Cosmic Bodies
or
“Asteroids and Comets I’ve Known and Loved”

Dennis V. Byrnes*
February 24, 2004

*Principal Engineer, Deputy Manager
Navigation and Mission Design Section
Jet Propulsion Laboratory
Where We’ve Been

- Chronologically

  - Sept. 1985  Comet 21P/Giacobini-Zinner  ISEE3/ICE
  - March 1986  Comet 1P/Halley  Giotto, Vega, Japan, (ISEE3/ICE)
  - Oct. 1991  Asteroid 951 Gaspra  Galileo
  - July 1992  Comet 26P/Grigg-Skjellerup  Giotto
  - Aug. 1993  Asteroid 243 Ida (Dactyl)  Galileo
  - June 1997  Asteroid 253 Mathilde  NEAR
  - July 1999  Asteroid 9969 Braille  Deep Space 1
  - Feb. 2000  Asteroid 433 Eros  NEAR
  - Sept. 2001  Comet 19/P Borrelly  Deep Space 1
  - Nov. 2002  Asteroid 5535 Annefrank  Stardust
  - Jan. 2004  Comet 9P/Wild 2  Stardust
- **Comet 21P/Giacobini-Zinner**
  - First Small Cosmic Body Visited by a Spacecraft
  - 9/11/85

- **Comet 1P/Halley**
  - ISEE3/ICE retargeted to monitor the Solar wind upstream of Halley

- **Watch for the return of the ISEE3/ICE Spacecraft to near the Earth ca. Aug. 2014**

http://nssdc@gsfc.nasa.gov
Comet Halley

- Size - 16x8x8 km
- Photo - Giotto Flyby 3/13/86
- C/A Distance - 596 km
- Flyby Speed - >50 km/s
- Also visited by:
  - Soviet Union (Vega 1 & 2)
  - Japan (Sakigake and Suisei)
  - US (ISEE3/ICE)
- Watch for Halley to return again in 2062!

http://sci.esa.int/home/giotto/index.cfm
Giotto

- Retargeted to encounter Comet 26P/Grigg-Skjellerup on 7/10/92
- C/A Distance - ~200 km
Asteroid Gaspra

- First flyby of an asteroid
- Size - 19x12x11 km
- Photo - Galileo Flyby 10/29/91
- C/A Distance - 1601 km
- Flyby Speed - 8.0 km/s

http://galileo.jpl.nasa.gov
Asteroid Ida and Its Satellite Dactyl

- First Asteroid known to have a satellite

- Size - 55x20x24 km

- Photo - Galileo Flyby 8/28/93

- C/A Distance - 2400 km

- Flyby Speed - 12.4 km/s

http://galileo.jpl.nasa.gov
Mass Determination of Ida

- First asteroid mass/density estimate by actual measurement

- 2.0-3.1 gm/cm³

- Interesting Problem

Asteroid Dactyl

- Size - 1.6x1.4x1.2 km
- Photo - Galileo Flyby 8/28/93
NEAR Trajectory to Mathilde and Eros

- The first Discovery Mission
- Mathilde Flyby
- Eros Rendezvous
- Orbital Operations
- End-of-Mission: Landing!
Asteroid Mathilde

- Size - 66x48x46 km
- Photo - NEAR Flyby 6/27/97
- C/A Distance - 1200 km
- Flyby Speed - 9.9 km/s
- Mass/density determined: 1.34 gm/cm³

http://near.jhuapl.edu
Asteroid Eros

- **Size** - 33x13x13 km
- **Photo** - NEAR On Approach 2/12/00
- **Density** 2.7 gm/cm³

http://near.jhuapl.edu
Asteroid Eros
Asteroid Eros
Asteroids Mathilde and Eros

- Photo - NEAR

- To Scale in Size, not Brightness

- Eros is actually about six times brighter than Mathilde
Asteroid Braille

- Size - 2.2x1.0x? km
- Photo - Deep Space 1 Flyby 7/29/99
- C/A Distance - 26 km, closest flyby ever
- Flyby Speed - 15.5 km/s

http://nmp.jpl.nasa.gov/ds1
Comet Borrelly

- Size - 8x3x? km
- Photo - Deep Space 1 Flyby 9/22/01
- C/A Distance - 2171 km
- Flyby Speed - 16.6 km/s

http://nmjpl.nasa.gov/ds1
Stardust Trajectory

- First planned sample return
  - Dust from flyby captured in aerogel

- Asteroid Annefrank flyby

- Comet Wild 2 Flyby
  - Dust sample
  - Nucleus imaging

- Earth Return 1/15/06

AIAA Planetary Defense Conference: Protecting Earth from Asteroids
February 23-26, 2004
Asteroid Annefrank

- Size - 8x5x? km
- Photo - Stardust Flyby 11/2/02
- C/A Distance - 3300 km
- Flyby Speed - 7 km/s

http://stardust.jpl.nasa.gov/
Comet Wild-2

- Size - 5 km diameter
- Photo - Stardust Flyby 1/2/04
- C/A Distance - 240 km
- Flyby Speed - 6.1 km/s

http://stardust.jpl.nasa.gov/
QuickTime™ and a GIF decompressor are needed to see this picture.