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THE HALLEY ARMADA

ИНТЕРКОСМОС

INSTITUTE OF SPACE AND
ASTRONAUTICAL SCIENCE

esa
european space agency
agence spatiale européenne

IHW
INTERNATIONAL
HALLEY WATCH

NASA
National Aeronautics and
Space Administration

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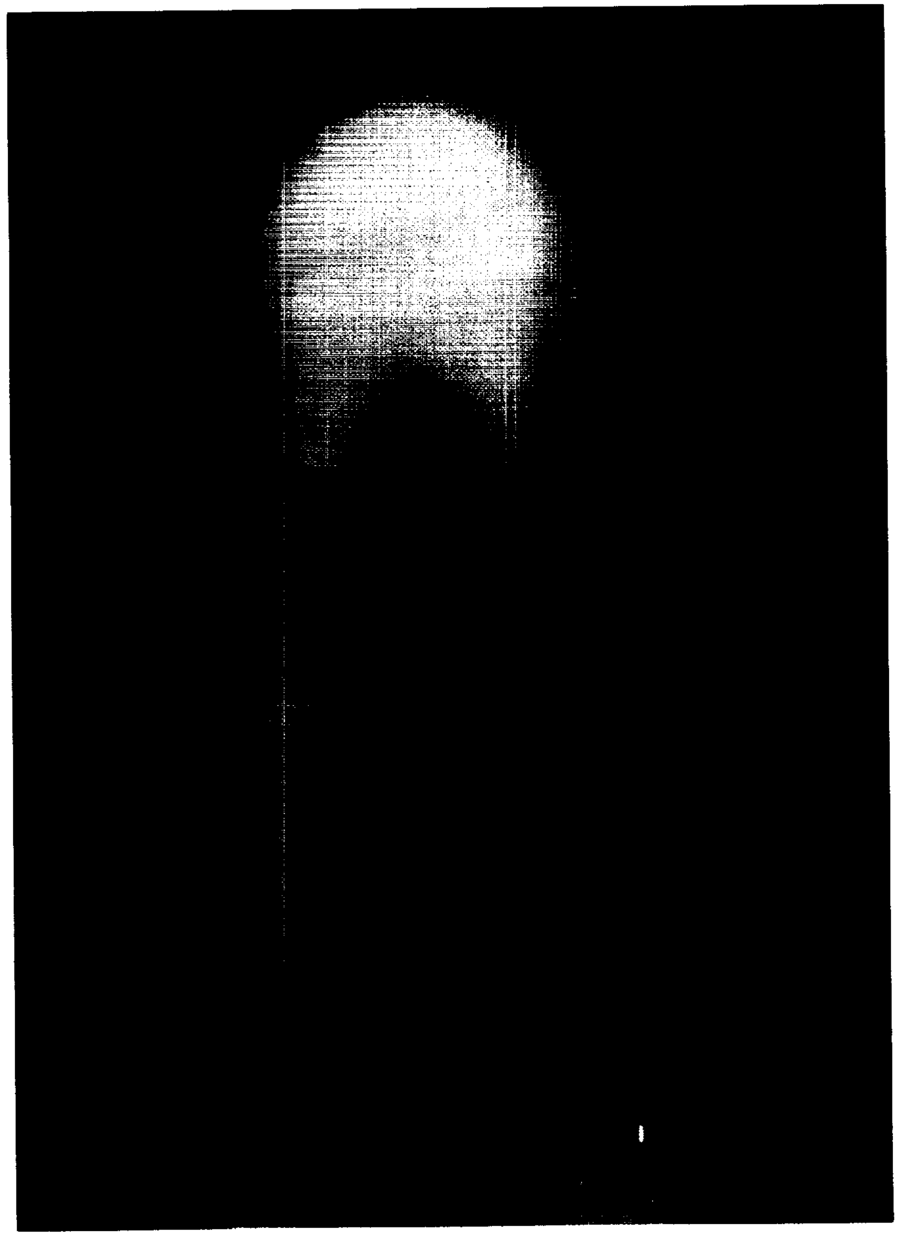
INTRODUCTION

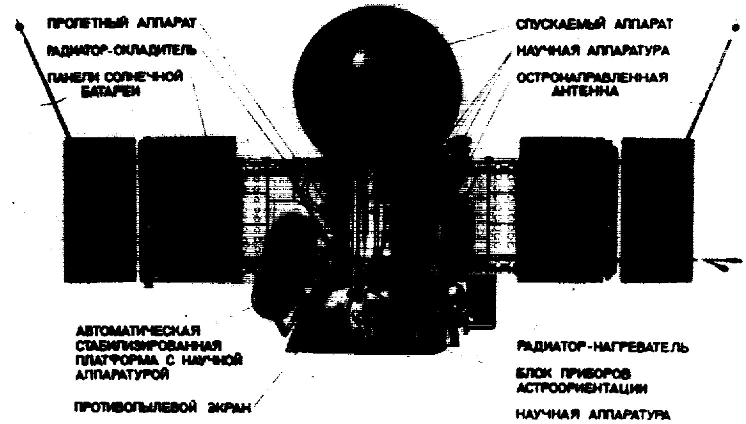
On February 9, 1986, Halley's Comet makes its 30th recorded perihelion passage of the Sun, but its first passage of the space age. It was inevitable that this most famous of all comets would receive unprecedented attention, but the actual magnitude of the effort has surprised even most of those involved in it. Coordination of the various international efforts in space and on the ground has been supplied by the Inter-Agency Consultative Group (IACG), whose single goal has been to maximize the scientific output of all participants. Some of the major components of the peaceful, scientific armada dedicated to Halley research are described briefly in this brochure.

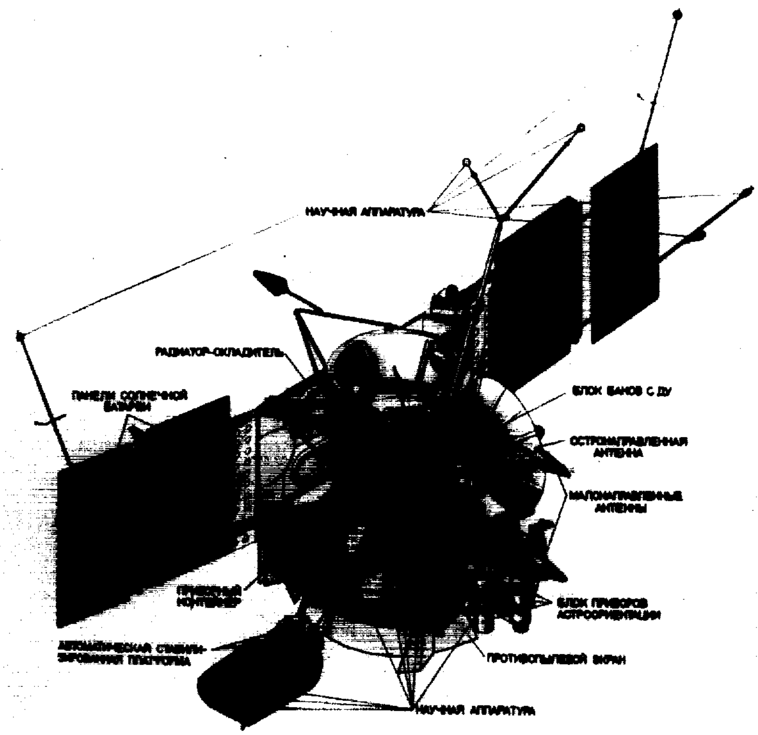


Comet Halley, 1910. (Mt. Wilson and Las Campanas Observatories)

U.S.S.R. VEGA SPACECRAFT

The Soviet Union launched identical VEGA spacecraft on December 15 and 21, 1984. Their interplanetary trajectories allowed flybys of Venus on June 11 and 15, 1985, during which each spacecraft successfully released a lander and an atmospheric balloon to explore the planet. VEGA 1 will encounter Comet Halley on March 6, 1986, at a velocity of 78 km/s and with a miss distance of 10^4 km. VEGA 2 will encounter the comet on March 9, 1986, with its final aim point being determined by results from VEGA 1.



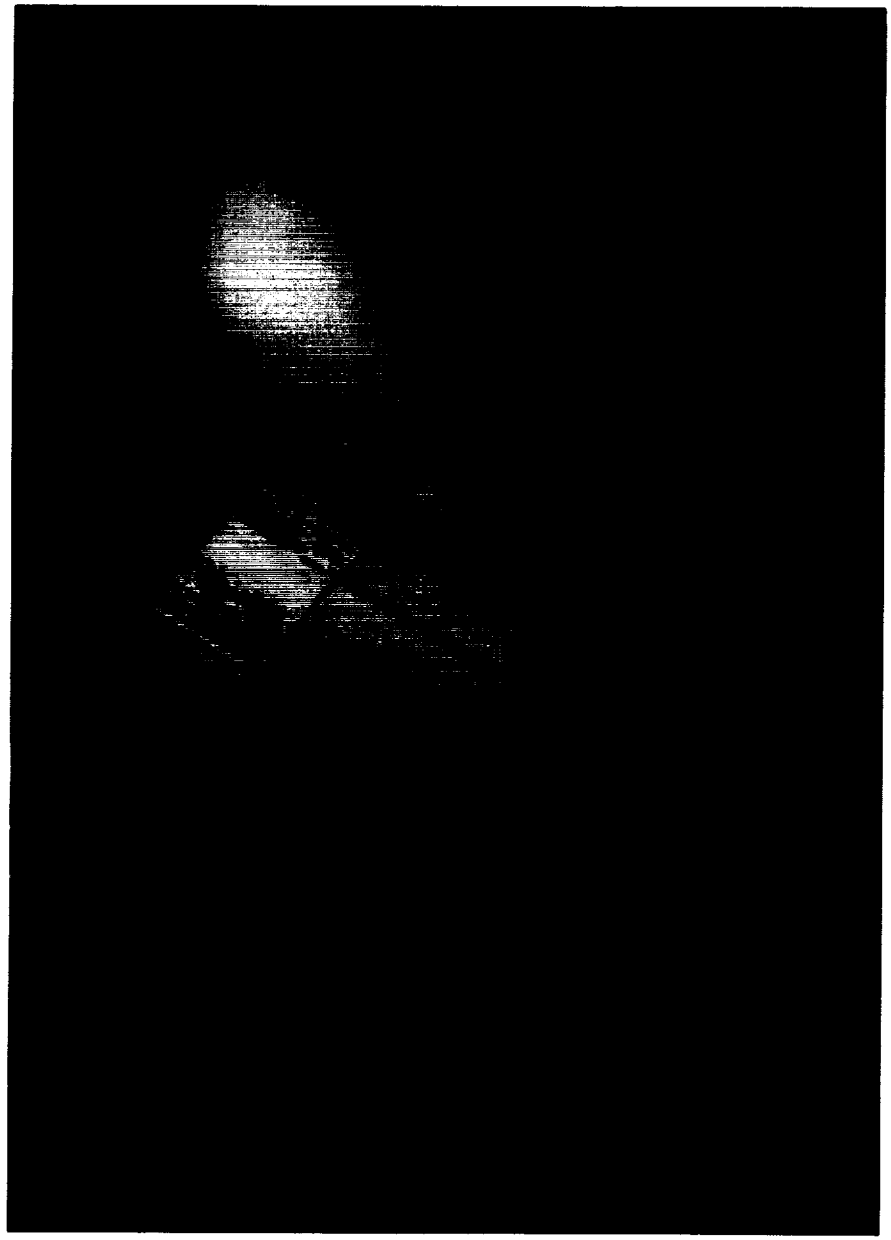


The VEGA spacecraft. (Soviet Academy of Sciences)

INSTRUMENT	*TYPE*	*MEASUREMENTS*
Imaging (2)	*Telescopes, 1200-mm and 200-mm focal length* *0°.4 x 0°.6 and 3°.5 x 5°.2 field-of-view* *Detectors, CCDs with multiple filters* *Best resolution ~180 m*	*Structure of nucleus and coma*
Spectrometer	*Three-channel, 0.12–0.35 μm, 0.35–0.9 μm, and 0.9–2.0 μm* *Spatial resolution 3 x 6 arcmin in ultraviolet and visible, 6 x 60 arcmin in infrared, all 1° field-of-view* *Spectral resolution 5 Å in ultraviolet, 10 Å in visible, and 120 Å in infrared* *Polarimetry in visible*	*Abundances and distribution of atoms, molecules, and ions in coma*
Infrared Spectrometer	*Three-channel, 4–8 μm, 8–16 μm, and 7–14 μm imaging* *Spatial resolution ~1 arcmin* *1° field-of-view* *Detector, HgCdTe at 80 K*	*Nucleus properties* *Temperature, size distribution, and abundance of dust in coma* *Parent molecule spectra*
Dust Mass Spectrometer	*Ionization-impact time-of-flight, M/ΔM ~150 for 1–110 amu*	*Composition from mass and number of component dust atoms*
Dust Counters (2)	*Metal plates each with three piezoelectric sensors for* $M \geq 10^{-10}$ *g* *Plasma cloud counter for* $M = 10^{-10}$–10^{-18} *g*	*Number and mass of impacting particles*
Neutral Gas Mass Spectrometer	*Time-of-flight*	*Number and mass of atoms and molecules in spacecraft vicinity*
Ion Mass Spectrometer (2 of 5 sensors)	*Electrostatic analyzer 1–150 amu, M/ΔM ~25, energy 15–3500 eV* *Cylindrical retarding potential analyzer*	*Flux, mass, and velocity of cometary ions*
Plasma Mass Spectrometer and Electron Analyzer (3 of 5 sensors)	*Electrostatic analyzers (2)* *3–5000 eV electrons* *50–25,000 eV ions* *Cylindrical retarding potential analyzer*	*Flux and energy spectrum of solar wind electrons and ions*
Energetic Particle Analyzer	*Semiconductor detectors (2)* *Anticoincidence scintillator* *175 keV–few MeV electrons* *20 keV–~30 MeV nucleons*	*High-energy solar and galactic particles, particles accelerated near comet*
Plasma Wave Detectors	*Low frequency antenna with Faraday trap, 0.1–100 Hz* *High frequency antenna, 0–300 kHz* *Langmuir probe*	*Flux of high and low frequency electromagnetic waves propagating in cometary plasma*
Magnetometers (2)	*Fluxgate type on 5-m boom* *Accuracy 0.1 nT*	*Ambient (DC) magnetic field*

EUROPEAN SPACE AGENCY GIOTTO SPACECRAFT

The European Space Agency (ESA) launched its Giotto spacecraft on July 2, 1985. Flyby of Comet Halley is scheduled for March 13, 1986, at a velocity of 69 km/s and at a distance of 500 km sunward from the comet's nucleus. This close targeting will be possible through the use of Intercosmos VEGA images for final navigation.

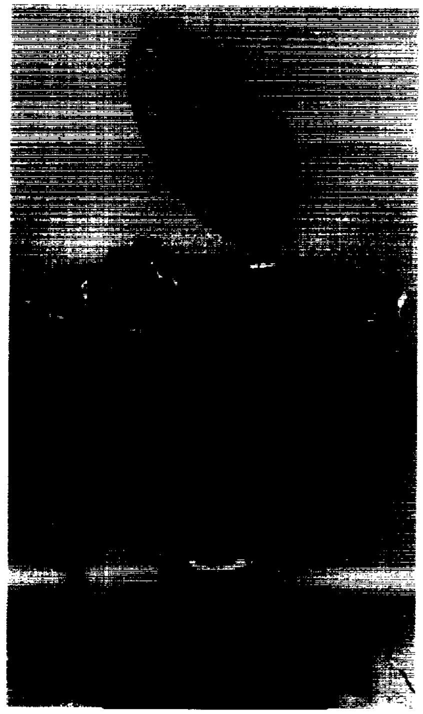


Giotto approaching Comet Halley. (George Jones, courtesy of Space Frontiers Limited)

INSTRUMENT	TYPE	MEASUREMENTS
Camera	Telescope, 960-mm focal length Detector, CCD 2°.3 field-of-view, 4 filters Ultimate resolution ~30 m	Images of nucleus and inner coma
Neutral Mass Spectrometer	Dual sensors (mass and energy) Sensitivity to 10 cm^{-3} High resolution 1–35 amu Moderate resolution to 86 amu	Abundance of each molecular mass of neutral gas
Ion Mass Spectrometer	High intensity range, up to 10^4 ions cm^{-3} for energies to 1.5 keV High energy range, up to 8 keV for densities up to 10^2 ions cm^{-3}	Abundance, mass, and energy of ions
Ion Cluster Composition	Electrostatic analyzer 10 to > 230 amu 10^{-3}–10^4 cm^{-3}	Mass analysis of positive ions and their hydrates
Dust Mass Spectrometer	Ionization-impact time-of-flight, $M/\Delta M$ ~150 for 1–110 amu	Abundance of chemical elements in the dust particles
Dust Impact Detector	Microphones for $M > 10^{-11}$ g Capacitor sensor for $M > 10^{-10}$ g Ionization sensor for $M > 10^{-16}$ g	Abundance and mass distribution function of coma dust particles
Optical Probe Experiment	Photopolarimeter 30-mm focal length, f/2.5 8 filters	Scattering properties of dust and spatial densities of gas and dust
Magnetometer	Triaxial ring-core fluxgate on antenna mast	Ambient (DC) magnetic field
Plasma Experiment	Fast ion sensor, all masses, 10 eV–20 keV Implanted ion sensor, six mass groups (1–45 amu), 100 eV–70 keV	Three-dimensional velocity distribution of positive ions
Energetic Particles	Surface barrier detectors Electrons ≥ 30 keV Protons ≥ 100 keV Particles (Z ≥ 2) ≥ 2.1 MeV	Energy spectrum and direction of energetic particles from the Sun, in Halley bow shock, and in ion tail
Electron Distribution	Quadrispherical electrostatic analyzer 10 eV–30 keV 360° x 4° field-of-view 1°.4 resolution $\Delta E/E$ ~0.1 ΔT ~2 s	Determine accurate angular distribution of suprathermal electrons at fast rate

JAPANESE SPACECRAFT

The Japanese Institute of Space and Astronautical Science (ISAS) has launched Japan's first two interplanetary spacecraft, one to study Comet Halley and one to monitor the solar wind environment in the comet's vicinity. Suisei, launched on August 19, 1985 (Japanese time), on its interplanetary trajectory to study Comet Halley, will encounter the comet on March 8, 1986, at a velocity of 70 km/s and a miss distance of less than 10^6 km. The Sakigake spacecraft was launched on January 8, 1985 (Japanese time), and will be within a few million kilometers of the comet in March 1986.



The Suisei spacecraft. (ISAS)

Launch of the Sakigake spacecraft on January 7, 1985. (ISAS)

SUISEI PAYLOAD

INSTRUMENT	TYPE	MEASUREMENTS
Ultraviolet Camera	Ultraviolet telescope $2\overset{\circ}{.}5 \times 2\overset{\circ}{.}5$ field-of-view Resolution 1 arcmin/pixel Intensified CCD detector, detection limit 1 kR at $L\alpha$	Abundance and distribution of hydrogen in coma by study of $L\alpha$ (1216 Å)
Solar Wind Experiment	Spherical electrostatic energy analyzer $5^\circ \times 60^\circ$ field-of-view 30 eV–16 keV in 96 steps	Energy and direction of electrons and ions

SAKIGAKE PAYLOAD

INSTRUMENT	TYPE	MEASUREMENTS
Solar Wind Ions	Faraday cup, collection area 70 cm^2 at zero angle of attack	Ion temperature Ion density Bulk velocity
Magnetometer	Triaxial fluxgate of ring-core type on 2-m boom Sensitivity < 0.1 nT	Ambient (DC) magnetic field
Plasma Wave Probe	Dipole antenna, 10-m length, for electric field measurements Search coil, 10^5 turns, ferrite core for magnetic field, frequency range 70 Hz–200 kHz	Plasma waves Radio bursts Auroral radiation Bernstein waves

U.S. INTERNATIONAL COMETARY EXPLORER SPACECRAFT

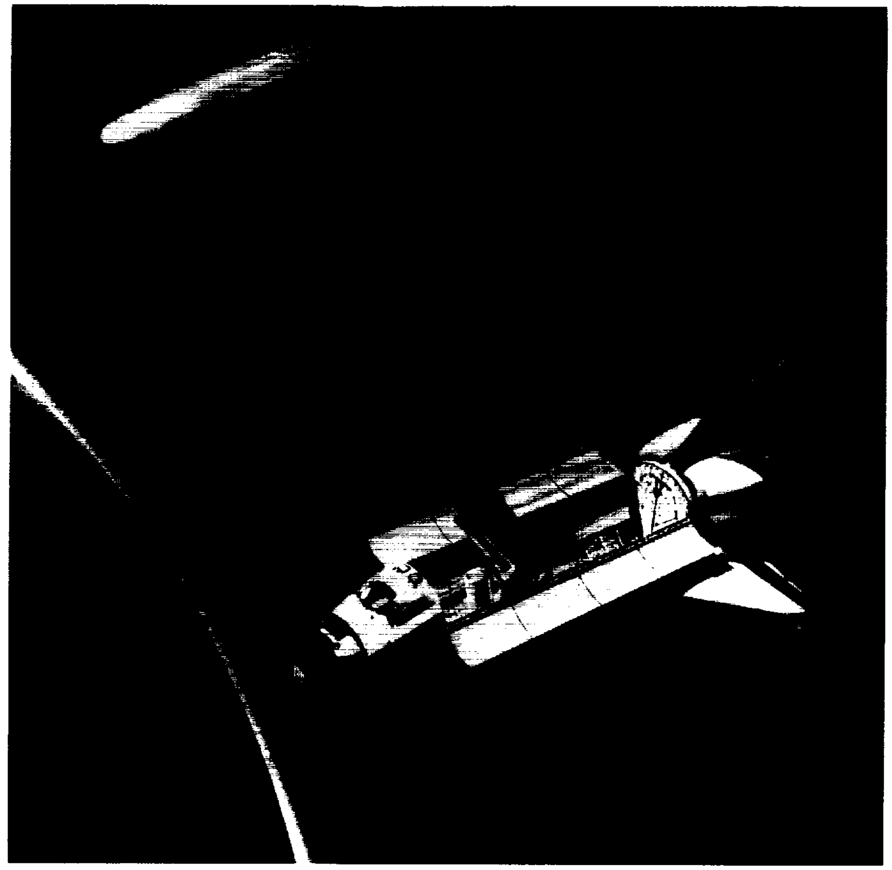
From 1978 to 1982, this NASA spacecraft, originally known as the International Sun–Earth Explorer 3 (ISEE-3), monitored the solar wind near the Earth–Sun Lagrangian L_1 point. In 1982 and 1983, a series of maneuvers in the Earth–Moon system culminated in a final close flyby of the Moon on December 21, 1983. This flyby sent the now renamed International Cometary Explorer (ICE) spacecraft on an interplanetary trajectory to fly through the tail of periodic Comet Giacobini-Zinner on September 11, 1985, 10,000 km from the nucleus, at a velocity of 21 km/s. In March 1986, the spacecraft will monitor the solar wind some 3 × 10^7 km from Comet Halley.

ICE studying Comet Giacobini-Zinner.

MEASUREMENT	INSTRUMENT	CAPABILITIES
Plasma Electrons	Spherical section electrostatic analyzer	$5 \leq E_e \leq 1500$ eV in 16 steps Two-dimensional distribution in one spacecraft revolution Sample every 12 s
Plasma Ions	Wien filter velocity selector Electrostatic analyzer	M/Q: 4–50 in 25 steps V: 20–200 km s^{-1} in 25 steps Sample every 20 min
Energetic Protons	Three solid-state telescopes aligned to spin axis at 30°, 60°, 135°	30 keV $\leq E_p \leq$ 1.4 MeV 8 channels, 8 sectors Complete sample in 16 s
Magnetic Fields	Vector helium magnetometer	Ranges: ±4, ±14, ±42 nT, etc. Precision: 0.016, 0.055 nT, etc. Accuracy 0.1 nT 6 triaxial samples s^{-1}
Plasma Waves	Long and short electric field antennas Search coil	$20 \leq f(E) \leq 10^5$ Hz 16 channels sampled in 0.5 s $1 \leq f(B) \leq 10^3$ Hz 8 channels sampled in 16 s
Radio Waves	Orthogonal electric field antennas parallel, perpendicular to spin axis	30 kHz $\leq f \leq$ 1 MHz Δf = 3 kHz in 12 steps 40 kHz $\leq f \leq$ 2 MHz Δf = 10 kHz in 12 steps Each scan: 28 s

U.S. ASTRO-1 MISSION

Astro-1 is a collection of instruments designed for astronomical observations from low Earth orbit. Carried aloft by a Space Shuttle on March 6, 1986, the telescopes in the payload will study the comet for the available period during each orbit.

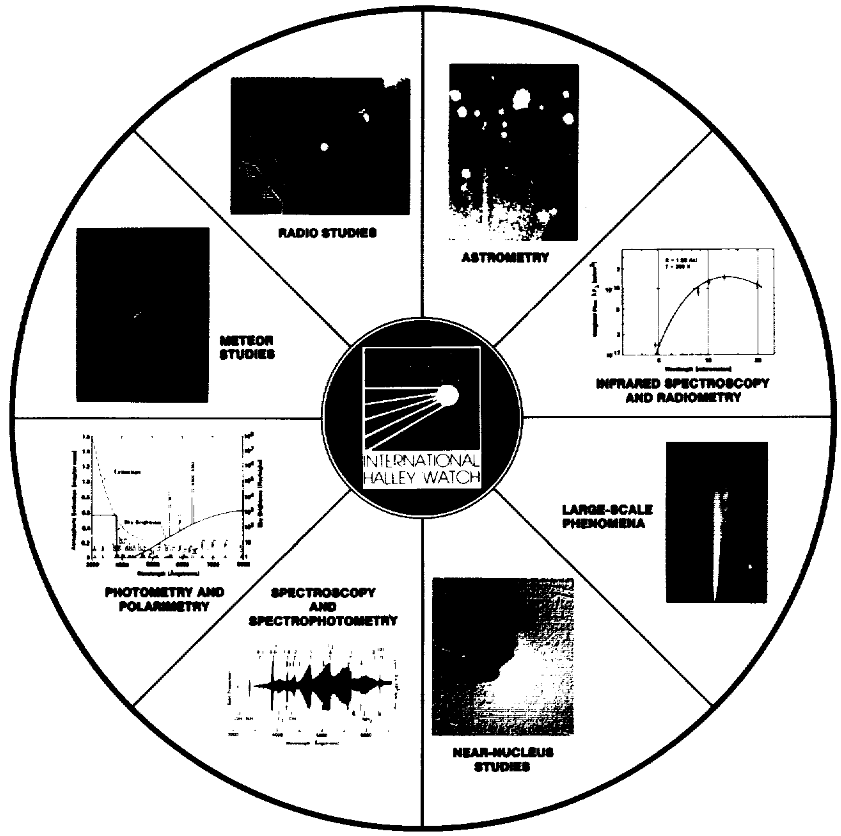


Astro-1 aboard a Space Shuttle.

INSTRUMENT	*MEASUREMENTS*
Hopkins Ultraviolet Telescope (HUT)	*Spectra from 425 to 1850 Å*
Wisconsin Ultraviolet Photopolarimeter Experiment (WUPPE)	*High spatial resolution photometry and polarimetry from 1300 to 3300 Å*
Goddard Space Flight Center Ultraviolet Imaging Telescope (UIT)	*High angular resolution imaging from 1216 to 3200 Å*
Wide-Field Cameras [2] *(WFC)*	*Tail photography from 3800 to 5000 Å and from 5000 to 6500 Å*

INTERNATIONAL HALLEY WATCH

The International Halley Watch (IHW) was organized in 1981 to coordinate ground-based study of Comet Halley and to assist Halley space missions where possible. Its goals are to (1) advocate studies of the comet by any scientifically valid means, (2) coordinate the activities of ground-based observers to maximize the scientific return of all investigations, (3) set useful standards for observations, (4) place the spacecraft missions in the context of overall cometary behavior, and (5) archive all the properly documented data collected during the Halley apparition. The scope of the Halley Watch has been broadened to include a Giacobini-Zinner Watch in support of the International Cometary Explorer.

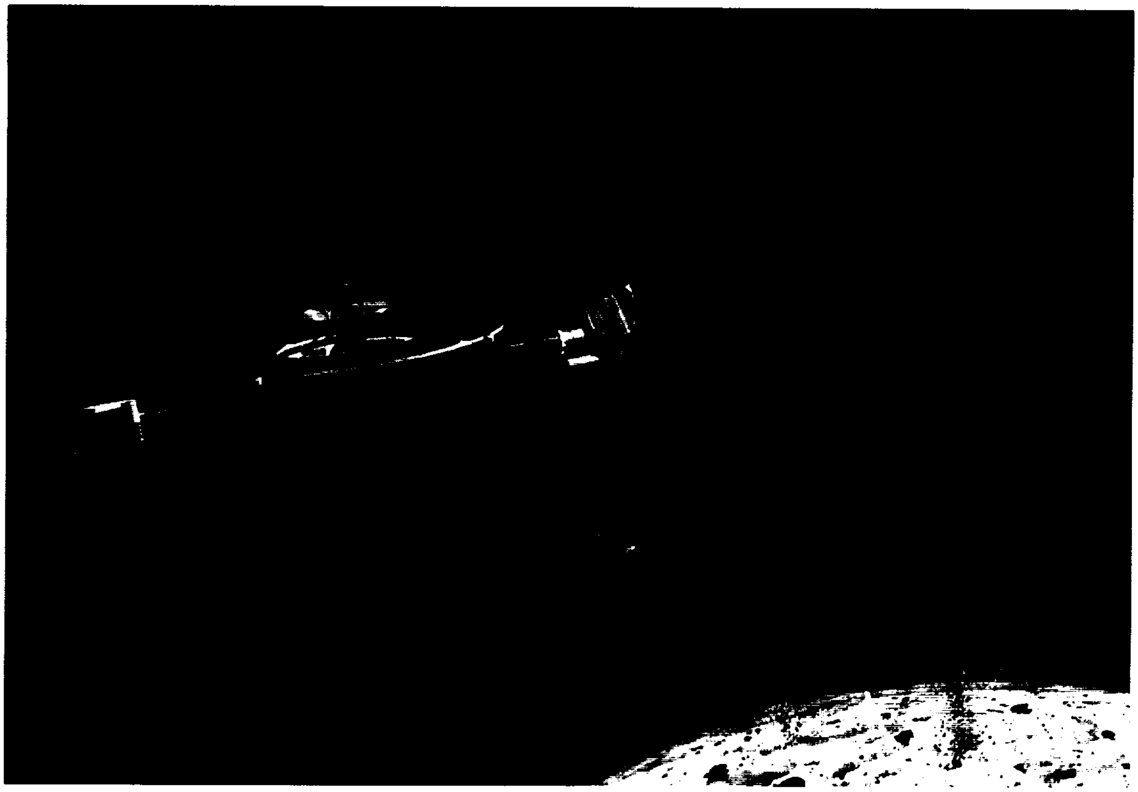


The International Halley Watch disciplines.

IHW RESEARCH AREAS

DISCIPLINE	*STUDIES*
Astrometry	*Orbital elements and evolution, ephemerides, nucleus and nongravitational forces*
Infrared Spectroscopy and Radiometry	*Dust particle temperature and size distribution, albedo and energy balance, gas composition*
Large-Scale Phenomena	*Morphology of ion and dust tails, tail interactions with solar wind and radiation*
Meteor Studies	*Density, mass, and composition of Halley meteor streams (Orionids and Eta Aquarids)*
Near-Nucleus Studies	*Dynamics of dust, ion, and neutral gas flows near nucleus, nucleus morphology and dynamics*
Photometry and Polarimetry	*Abundances and distribution of major volatiles and nonvolatiles*
Radio Studies	*Gas production and composition, study of nucleus by radar (if possible), plasma studies*
Spectroscopy and Spectrophotometry	*Chemical and isotopic composition, gas temperatures and velocity*

THE NEXT MISSION: COMET RENDEZVOUS



NASA

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