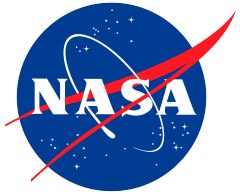

Helios Mini-Workshop

The Legacy of HELIOS:
Why is Helios Important Now and Creation of a Universal Archive at NASA

Chadi Salem

Space Sciences Laboratory, University of California Berkeley

Jan Steinhagen, Lars Berger and Robert Wimmer-Schweingruber

Institut fuer Experimentelle und Angewandte Physik, University of Kiel, Germany

Thierry Dudok de Wit

LPC2E, Université d'Orléans, Orléans, France

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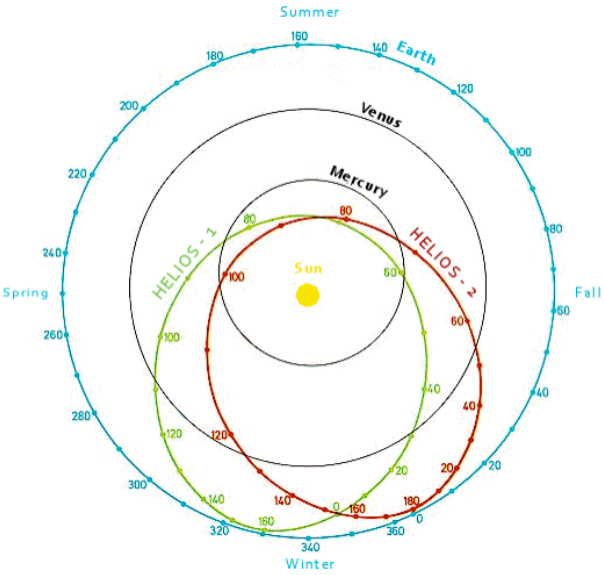
The Helios mission

Aimed at investigating the properties and processes in interplanetary space by approaching the sun to 0.3 AU

- Helios 1: launch on 12/10/1974; orbit with a period of 190 days; perihelion of 0.31 AU and aphelion of 0.99 AU.
- Helios 2: launch on 1/15/1976; orbit with period of 187 days and perihelion of 0.29 AU and aphelion of 0.98 AU.
- Almost identical instrumentation on both s/c. Each was equipped with 2 booms and a 32m electric dipole antenna.
- Both s/c are spin-stabilized with the spin axis perpendicular to the Ecliptic plane and a spin period of 1 sec. Spin of H1 pointing north and that of H2 south.
- Operations ceased for Helios 2 on March 21, 1980 and for Helios 1 on March 1986.
- Plasma measurements: protons (+alphas) and electrons, but slow sampling of VDFs and low phase space resolution.
- No Composition! No Imaging!



Highly elliptical trajectory of the Helios space probes

Instruments and measurements

Investigation	Principal Investigator	Measurements
Flux-Gate Magnetometer	(1) Musmann, Neubauer, (2) Mariani, Ness	Magnetic field strength and direction of low-frequency magnetic fields in the inner heliosphere
Search-Coil Magnetometer	Dehmel, Neubauer	Complement of the Flux-Gate Magnetometer by measuring the magnetic field fluctuations up to 3 kHz
Plasma Particles	Rosenbauer, Schwenn	Velocity distribution functions of solar wind protons, alpha-particles and electrons
Plasma Waves	(1) Gurnett, (2) Kellogg	Electric field of plasma waves in the solar wind from 10 Hz to 3 MHz
Cosmic Rays	Kunow, Trainor	Energetic protons, electrons and x-rays to determine the distribution of cosmic rays
Low-Energy Cosmic Rays	Keppler	Higher energy portion of the crossover region between solar wind particles and cosmic rays.
Zodiacal Light Photometer	Leinert	Scattering of sunlight by interplanetary dust particles
Micrometeoroid Analyser	Grün	Composition, charge, mass, velocity and direction of interplanetary dust particles

Instrumentation: summary

Tabelle 1: Übersicht über die Experimente auf Helios

Nr.	Thema	Experimentatoren	Institut
1	Sonnenwind	H. ROSENBAUER, R. SCHWENN	MPI für Physik und Astrophysik, Institut für extraterrestrische Physik, Garching
		J. H. WOLFE	NASA Ames Research Center
2/4	Interplanetares	G. MUSMANN, G. DEHMEL, F. M. NEUBAUER, A. MAIER	TU Braunschweig, Institut für Geophysik und Meteorologie
3	Magnetfeld	N. F. NESS, L. F. BURLAGA	NASA Goddard Space Flight Center
		F. MARIANI	Universität Rom, Istituto di Fisica
5	Elektrische	D. A. GURNETT	Un. of Jowa, Dep. of Physics and Astronomy, Jowa City
	Felder,	P. J. KELLOGG	Un. of Minnesota, School of Physics and Astronomy, Minneapolis
	Radiowellen	R. R. WEBER	NASA Goddard Space Flight Center
6	Kosmische	H. KUNOW, G. GREEN, R. MÜLLER, G. WIBBERENZ	Un. Kiel, Institut für Reine und Angewandte Kernphysik
7	Strahlung	J. H. TRAINOR, K. G. MCCRACKEN	NASA Goddard Space Flight Center
		F. B. MCDONALD	Un. of New Hampshire
		E. C. ROELOF, B. J. TEEGARDEN	SCIRO, Melbourne, Australien
8	Strahlung mittlerer Energie	E. KEPPLER, G. UMLAUFT, B. WILKEN	MPI für Aeronomie, Lindau
		WILLIAMS	ESSA, Boulder
9	Zodiakallicht	C. LEINERT, H. LINK, E. PITZ	MPI für Astronomie, Heidelberg
10	Mikrometeoriten	E. GRÜN, P. GAMMELIN, J. KISSEL	MPI für Kernphysik, Heidelberg
11	Relativitätstheorie	W. KUNDT, O BÖHRINGER	Un. Hamburg, Institut f. Theor. Physik
		W. G. MELBOURNE, I. D. ANDERSON	JPL, Pasadena
12	Faraday Rotation	H. VOLLAND, M. BIRD	Un. Bonn, Radioastron. Institut
		G. S. LEVY	JPL, Pasadena
12 Z	Elektronendichte der Korona	P. EDENHOFER, E. LÜNEBURG	DFVLR Oberpfaffenhofen

1. Plasma Experiment

2 and 3. Flux-gate Magnetometers

4. Search Coil Magnetometer

5. Plasma Wave Experiment

6 and 7 Cosmic Radiation Experiments

8 Low-Energy Electron and Ion Spectrometer

Zodiacal Light Photometer

Micrometeoroid Analyser

Helios: History and Accomplishments

- Helios ranks among the most important missions in Heliophysics and the more than 11 years of data returned by its spacecraft remain of paramount interest to researchers.
- Their unique trajectories, which brought them closer to the Sun than any spacecraft before or since, enabled their diverse suite of in-situ instruments to return measurements of unprecedented richness.
- Analyses of these measurements produced groundbreaking insights into:
  - the large-scale spatial and temporal variations in the inner heliosphere
    [Marsch 1991, Marsch 2006]
  - solar wind turbulence across both MHD and kinetic scales
    [Marsch 1991, Bruno and Carbone, 2005, 2013]
  - the effects of kinetic instabilities
    [Marsch et al. 1982a; Marsch & Livi, 1987, Gurnett 1991]
  - the process of collisional thermalization [Marsch et al. 1982b] and ongoing heating processes [Schwartz and Marsch, 1983]
  - Energetic Particle Acceleration and Transport.

Most of our knowledge of solar wind plasma and magnetic field in the inner Heliosphere comes from the Helios mission

Relevance to SPP/Solar Orbiter

- The importance of Helios to the upcoming SPP and Solar Orbiter (SO) missions is evidenced even in the planned trajectories of these new spacecraft.

- Radial trends produced from the Helios in-situ measurements were invaluable to the SPP and SO instrument teams for making their preliminary designs and continue to be used as they finalize their designs and develop observing plans. This work involved integrating predictions from various theoretical models into a multi-instrument analysis of Helios data, which was extrapolated from the Helios perihelia (0.31 and 0.29 AU) to the SPP perihelion (10 Rs ~ 0.05 AU).

- No comprehensive public repository of all Helios in-situ data is available. Also, very little documentation is available, especially on calibration.

- A careful examination of some of the data raised some questions/concerns. Quantitative analyses of this data set requires overcoming a number of technical and instrumental issues.

- Project of restoration and re-calibration of the Helios data at SSL/UCB.

Current Project with the HELIOS data

Project funded by NASA for 2 years (PI Salem). The goal is:

- To aggregate ALL in-situ Helios 1 and 2 data still available today.
- To look at the data, analyze and make sense of it, identifying and understanding various issues with the data.
- To reprocess and re-calibrate it, if possible.
- To create a single archive of calibrated multi-instrument Helios data.
- To write comprehensive documentation detailing the data available and describing the various issues/uncertainties etc.
- To produce and make available software to download and analyze the data from the Archive.

Current Work with Kiel

- Helios 1 & 2 E1, E2, E3, E4, E5 and E6 data is being gathered.

- E2 and E3 data are under intense analysis and scrutiny to understand the important magnetic field measurements. A lot of work is being done with the team at the university of Kiel. The raw, original, data sets are lost forever. Only processed & "calibrated" data are available at different resolutions, which show some discrepancies. Therefore a detailed comparison of different data sets from different sources is necessary to understand the processing that has been done to the data. The hope is to fix what is wrong with the data, if at all possible. (***cf Presentation by Jan Steinhagen***)

- E1 data is available. "Fluid" moments are somewhat unreliable and need to be reprocessed after a thorough analysis of the proton, alpha and electron distribution functions. This is a large enterprise, and it will be undertaken sometime in the future (new 2016 NASA HDEE proposal).

Current Work with Kiel - 2

- E4 data is a problematic. Colleagues at Orleans experienced difficulties reading the data stored in binary files (***cf Thierry Dudok de Wit***).
- E5 data has been archived and documented at Univ. of Iowa and I have access to it. It will be added to the full archive.
- E6 (energetic particle data) is available at resolutions down to 15 min at Kiel in a few CDs/DVDs, and will eventually be added to the archive.
- A Wiki document has been started this month to document all issues with the data for E1/E2/E3/E4 experiments.
- This workshop will be helpful to develop and complete the wiki with as much information as possible on the state of the data.
- Let's also talk about applying for an ISSI group on "Reanalysis, Recalibration and Long Term Preservation of Helios 1 & 2 data".

Current work with Kiel - 3

- Also, a great effort of gathering ALL possible documentation on all instrument and data sets available are underway, along with the original instrument papers and any other form of documentation (PhD thesis, reports, etc.).

- The most of important ones are the so-called blue books, written in the early to mid 80s, describing the data sets, and in most cases the processing and massaging of the data. These are all in German. Kiel is planning to hire a student to scan them.

- All these documents will be added to the archive.