7. *Joint Observations and Observing Campaign*

Research Objectives for FY2002-2004 from the Ulysses 2001 Senior Review Proposal

(1) Analyze Jovian radio emissions for source locations and characteristics of low frequency emissions and renew studies of Jovian electron escape and propagation. Ulysses will be located at unexplored northern jovicentric latitudes. The northern hemisphere is the more active in radio emissions.

(2) Test models for energetic particle, neutral gas, and dust release from Jupiter's magnetosphere.

(3) Analyze Saturnian radio emissions in 2004, when Cassini will observe Saturnian kilometric radio (SKR) emissions just before it enters the magnetosphere. Ulysses will be less than 7 AU from Saturn. Simultaneous observations will determine the size and shape of the instantaneous radio beam and local time variations of SKR.

(4) Conduct observations with SOHO when it is in quadrature with Ulysses and the Sun. Study the relationship between coronal structure and 3D heliospheric structure after solar maximum.

(5) Conduct quadrature observations with upcoming spacecraft - STEREO, Solar-B, and SDO.

(6) Conduct observing campaigns of opportunity when there are meridional and radial alignments of Ulysses with other spacecraft.

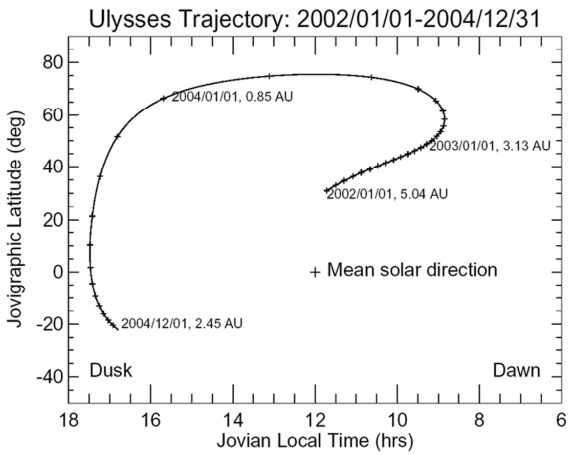

Figure 7.1. The trajectory of Ulysses viewed from the perspective of Jupiter (in jovicentric coordinates). The relative positions of Jupiter and Ulysses provide this unique opportunity to scan a wide range of Jovian local times and latitudes.

Accomplishments in 2001-2003 and Objectives for 2004-2005 and 2006-2007

Quadratures:

Ulysses/SOHO quadrature observations have been made twice a year since 1997. In 2004-2007, the objectives will be low latitude wind from near the boundaries of coronal holes - both high speed and low speed states. STEREO and Solar-B will be launched in 2005 and SDO in 2007. Quadratures will occur twice a year for Solar-B and SDO. They will occur approximately twice a year *for each* of the two STEREO spacecraft.

Jovian Flyby:

Ulysses made important contributions to the study of the Jovian magnetospheres both during the Jupiter close flyby and when far from the planet. New Jovian radio components have been discovered, including bursts that reoccur with ~15 minutes and ~40 minutes quasi-periodicities and elliptically-polarized radio emissions at kilometric wavelengths.

Ulysses will approach to within 0.85 AU of Jupiter on February 5, 2004. This distant flyby will

Table 7.1 Analyses of Jovian Emissions: 2003-2004

Jovian emission	*Source location*	*Observing Targets (with references to 1992 flyby)*
Energetic ions & electrons	Jovian bow shock or magnetosphere	North-south asymmetries, solar cycle variations, & probing IMF structures [Haggerty and Armstrong, 1999]
Dust (scales ~ 1 nm)	Io's volcanoes	Monitor Io's volcanoes [Graps et al., 2000], compare high latitude data with Galileo & Cassini, test 3-D models of dust grain dynamics and interaction with magnetospheric and IP magnetic fields [Zook et al., 1996]
Neutral gas	Jupiter, moons	Latitudinal dependence, important in modeling Jovian mass and energy losses [Witte et al., 1997]
Kilometric radio emissions	Field lines through aurora or torus	Determine source locations and characteristics; understand time variability
Quasiperiodic radio and X-ray bursts	Polar cap(s?)	Compare burst periodicity, phase, morphology, etc., for both poles to improve understanding of periodic electron acceleration to relativistic energies [MacDowall et al., 1993]
Radio burst triggering	Solar wind effects on kilometric radio emissions	Improve understanding of burst triggering by solar wind transient and corotating structures [Reiner et al., 2000]; use burst as a proxy to study other solar wind interactions with the magnetosphere

Table 7.2: *Topical summary of 2004-2007 objectives - Joint Observations and Campaigns*
▪ Analyze Jovian radio emissions for low frequency source locations and emission characteristics using Ulysses' location at jovicentric latitudes never before visited. (2003-2004)
▪ Renew studies of Jovian electron escape and propagation. (2003-2004)
▪ Test models of the release of energetic particles, neutrals, and dust from Jupiter's magnetosphere. (2003-2004)
▪ Analyze Saturnian radio emissions. In 2004, the Cassini spacecraft will observe Saturnian radio emissions well before it enters the Saturnian magnetosphere. (2004-2005)
▪ Conduct observations with SOHO when it is in quadrature with Ulysses and the Sun. Study the relationship between coronal structure and 3-D heliospheric structure during reformation of coronal polar holes. Also conduct quadrature studies with STEREO, Solar-B, and SDO. (2003-2008)
▪ Conduct observing campaigns when there are meridional and radial alignments of Ulysses with other spacecraft. (when the opportunity occurs)

allow studies of the release and interplanetary propagation of Jovian electrons in regions of circum-Jovian space not previously sampled. The highly inclined orbit will provide an extended opportunity to observe energetic particles, dust, neutral gas, and radio waves from a wide range of high northern latitudes. The trajectory (Fig. 7.1) remains above 50° N jovicentric latitude for almost one year. These observations will constrain models of emission from the Jovian magnetosphere [Simpson et al., 1993] and, supported by the Ulysses solar wind and magnetic field observations, provide an opportunity to study Jupiter's response to solar wind inputs (Table 7.1).

Jovian radio emissions:

Solar transients can be tracked by enhancements of planetary radio emissions when the transient impacts the planetary magnetosphere. Jupiter is the most intense source and Ulysses routinely detects Jovian arrival of solar wind transients [MacDowall et al., 1993]. The phenomena will be observable again in 2003-2004 when Ulysses is within 3 AU of Jupiter. Of particular interest are periodic auroral phenomena which produce both radio and X-ray bursts. The quasiperiodic X-rays, observed by the Chandra X-ray Observatory [Gladstone et al., 2002], came primarily from the northern hemisphere, whereas the original Ulysses observations in 1992-3 corresponded to radio bursts from the southern polar cap.

Saturn/Cassini:

In late 2004, the Cassini spacecraft will reach Saturn. Ulysses will be less than 7 AU from the planet and can carry out comparative studies of Saturnian radio bursts with Cassini. Ulysses already routinely detects SKR and has provided considerable evidence that the Saturnian rotation period deduced from periodicities in the radio emission is not constant, a result that still requires a complete explanation [Galopeau and Lecacheux, 2000].

8. *Science Summary*

The scientific productivity of Ulysses has been good in 2000-2003. Investigators have published papers under all of the objectives except the hoped-for, but absent, flare equaling the 1991 X-ray flare. In addition to refereed publications, the Ulysses Team has participated in special meetings, a book has been published [Balogh et al., 2001], two ESLAB symposia have been published as books [Marsden, 1995, 2001], a solar maximum results summary article is in press in *Science*, and *Geophysical Research Letters* and *Annales Geophysicae* special issues are in press at the time of this writing. Ulysses investigators continue to be very active and we are proposing extended or additional science objectives in all of the theme areas. Bolstering our own plans are many independent studies that have been funded under NASA LWS, SR&T, and GI programs. We have not attempted to poll the use of Ulysses/GRB data but those studies are also very popular. Many of them are included in the on-line bibliographies (helio.esa.int/ulysses/ and ulysses.jpl.nasa.gov/, under Science:Publications) supplementing this proposal.

Ulysses has stimulated, and continues to stimulate frontier research on sources of the solar wind, the Sun and the heliosphere as an integrated system, the 4D heliosphere, and the local interstellar medium. We are confident that Ulysses will remain the touchstone for this research that it is today.