ODIN: A SWEDISH SUBMILLIMETER WAVE SPECTROSCOPY SATELLITE FOR ASTRONOMY AND AERONOMY

ÅKE HJALMARSON
Onsala Space Observatory, S-439 92 Onsala, SWEDEN

Abstract. The salient features of ODIN—a mm/submm wave satellite for astronomy and aeronomy—are presented. Differences with respect to SWAS are emphasized. The ODIN project is a joint venture between the space agencies and scientific communities in Canada, Finland, France, and Sweden ("majority shareholder"). The project cost is estimated to fall below 50 M$ and we aim at launch in October 1997.

1. Prologue

Since this presentation is scheduled for such a late hour, I have decided to begin by telling you a bedtime story, which is true and, hopefully, will have a happy ending. Once upon a time—I think it was five years ago—there gathered in the remote snowy kingdom of Sweden a rather wild tribe of astronomers and aeronomers, who had a strong common desire to conquer (not their neighbours but) space by means of a very sensitive submillimeter wave satellite. Their desire was to launch a machine containing an SIS mixer supported by a 4K cooler from the European Space Agency. This would require the space qualification of such a system and would be very useful for ESA's cornerstone FIRST. But confronted with "those evil ghosts and witches"—normally found in bedtime stories—here, in terms of the reality provided by the Swedish Space Company and National Space Board, the aforementioned tribe very soon realized that their desire would be much too expensive in terms of weight and power, and hence money. Subsequently, the Swedish tribe arrived at a more realistic desire (to be described below) and has joined forces with tribes of similar origin in Canada, Finland, and France. We now struggle together towards a happy ending (or rather beginning!!), i.e., a satellite launch in late 1997.

2. Main Scientific Drivers

ODIN will work in unexplored bands of the electromagnetic spectrum around 0.5 and 2.5 mm, where ground-based observations are hindered by atmospheric absorbtion due to H_2O and O_2. Observations of the very same molecules are the main astronomy drivers of the mission, aiming at an improved understanding of interstellar oxygen chemistry and of the cooling processes governing molecular cloud evolution towards star formation. The major aeronomy driver is ozone chemistry. A limb scanning mode will be used for studies of the distributions of O_3, ClO, CO, H_2O, O_2, and other molecules as well as aerosols in the terrestrial atmosphere. Here complementary observations will be performed at ultraviolet, optical and near infrared wavelengths.

3. Payload Overview

Also, in this more conservative approach, we still try to emphasize sensitivity. Active cooling is employed (although only to 80K) and the antenna size has been "maximized" (but still to fit a Pegasus XL launcher). To gain at least an order of magnitude in O_2 abundance sensitivity for extended (nearby) cold molecular clouds, compared to what is achievable with the submm line, we have managed to include a low noise 119 GHz HEMT amplifier channel. The main ODIN payload features are:

- A 1.1 meter offset Gregorian antenna (surface rms below 10 μm)
  - Beam size: $2'$ at 0.5 mm, $9'$ at 2.5 mm
  - Resolution: 2 km at 0.5 mm, in aeronomy mode
- Tunable Schottky mixers (tuning range $\pm 1.5\%$), centered at
  - 572 GHz (O_3, ClO, CO, NH_3, H_2S)
  - 555 & 549 GHz (H_2O, $H_2{}^{18}O$, ^{13}CO, $C^{18}O$)
  - 495 GHz (H_2O, HDO, ClO, O_3, O_2, CI, CS)
- HEMT amplifier / Schottky mixer at 119 GHz (no tuning, just for O_2)
- Sterling cycle cooling to 80K, to reduce receiver noise
- Spectrometer capacity:
  - 2 high/low resolution hybrid autocorrelators (150kHz / 1 MHz)
  - Broad band AOS
- Simultaneous operation of ≥ 2 receivers using ≥ 2 spectrometers
- Grating spectrometers with 200 – 800 nm and 1270 nm bands (for aeronomy)

4. Differences between ODIN and SWAS

Since ODIN receivers will cover all lines to be observed by SWAS (NASA's Submillimeter Wave Astronomy Satellite), i.e., H_2O, $H_2{}^{18}O$, O_2, CI, and ^{13}CO, we will here emphasize important differences:

- ODIN is a joint Astronomy / Aeronomy mission
- ODIN's submm sensitivity is $\geq$3 times that of SWAS (antennas, cooling)
- ODIN carries *tunable* submm mixers—hence allowing spectral scans
- ODIN carries a 119 GHz HEMT channel, which will lead to an order of magnitude higher O_2 abundance sensitivity (for cold, extended regions)
- ODIN's launch is scheduled *two years later* than that of SWAS, hence we hope for very useful input information. In fact, collaboration between the SWAS and ODIN astronomy teams already exists in terms of a joint southern hemisphere molecular cloud survey at SEST—the Swedish ESO Submillimetre Telescope.

5. Astronomy Research

Most observing time will be spent on studies of interstellar H_2O (557 GHz), $H_2{}^{18}O$ (548 GHz), and O_2 (119 & 488 GHz)—missing links in our understanding of oxygen chemistry and cooling of molecular clouds. We foresee CO (5–4) and ^{13}CO (5–4) surveys to be valuable complements, especially in accounting for the PDR component of the molecular clouds. Density probing using the NH_3 ground state rotational transition (572 GHz) may be useful for the interpretation of the H_2O data.

We also plan to perform spectral scans—of bands not accessible from ground—towards a few selected molecular cloud cores and circumstellar envelopes (this is almost an "obligation", since we have tunable receivers). Some studies of circumstellar envelopes around late type stars, of atmospheric chemistry of planets, and of H_2O outgassing from comets are also being considered. Observations of H_2O and O_2 in some relatively nearby galaxies will be attempted. Here comparison of the interstellar medium in the Large Magellanic Cloud with the conditions in the Milky Way may be especially interesting.

Acknowledgements The substantial funding from the Swedish National Space Board and from the Swedish Natural Science Research Council—as well as the moral support provided by the ODIN community in terms of my "appointment" to act as Astronomy Mission Scientist—is very much appreciated.