BISTATIC RADAR TEST ACTIVITIES

AT THE ITALIAN MEDICINA RADIOTELESCOPES

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ABSTRACT

We describe the first intercontinental planetary radar test performed in Italy observing Near Earth Asteroid (NEA) 33342 (1998 WT24) in December 2001 by means of the bistatic configurations Goldstone(California, USA)-Medicina and Evpatoria(Ukraine)-Medicina.
The experiment goal was to characterise the system for realtime radar follow-up observations of NEAs and artificial orbiting debris, in the framework of a feasibility study which aims at using the Sardinia Radio Telescope, at present under construction, also as a planetary radar facility.

INTRODUCTION

We report the preliminary results of the radar observations carried out by the IRA-CNR (Istituto di Radioastronomia – Consiglio Nazionale delle Ricerche) and the OATo (Osservatorio Astronomico di Torino) groups, aimed at exploring the scientific potentials of a new space radar program, using existing facilities in Italy.
The planetary radar technique is uniquely capable of investigating geometry and surface properties of various solar system objects [1], demonstrating advantages over the optical methods in its high spatial resolution and ability to obtain three-dimensional images.
A single radar detection allows to compute extremely accurate orbital elements, improving the instantaneous positional uncertainties by orders of magnitude with respect to an optically determined orbit. Radar is a powerful means to spatially resolve NEAs by measuring the distribution of the echo power in time delay (range) and Doppler frequency (line-of-sight velocity) with extreme precision in each coordinate, as it provides detailed information about the target physical properties like size, shape, rotation, near-surface bulk density and roughness and internal density distribution[1].
The Medicina 32m antenna had been successfully used for the first time as the receiving part of a bistatic configuration during a test experiment (September 2001) held to check the capabilities of the entire data acquisition system. This test was possible thanks to the collaboration undertaken with the Evpatoria radar station, and consisted in the observation of the ETALON-1 low orbit satellite.

THE OBSERVATIONS

The Experiment Target and System Setup

The target of our observations was the NEA 33342 (1998 WT24), an Earth's crossing asteroid. The experiment was held when the asteroid, whose effective diameter is about 600 m, was at its minimum distance, being 1.87 10^6 km far from our planet.

In this bistatic radar experiment, radio signals at different wavelengths were transmitted from Goldstone (3.5 cm) and from Evpatoria (6 cm), while the radar echoes reflected from the asteroid surface were received by the 32m antenna in Medicina (Bologna – Italy). The bistatic radar configurations are shown in Table 1.

Table 1 - Antennas Configuration

	Goldstone (Tx)	**Medicina (Rx)**		**Evpatoria (Tx)**	**Medicina (Rx)**
λ (cm)	3.5	3.5		6	6
Diameter	70 m	32 m		70m	32m
Max Effective Area	2694 m^2	389.3 m^2		2520 m^2	466 m^2
Max G_{ant}	74.4	66.0 dB		74.1 dB	62.1 dB
Tsys	15 K	50 K		65 K	50 K
HPBW	2.3 ’	4.9 ’		3.6 ’	7.5’
Transmitted power	460 kW	---		150 kW	---
Transmitted frequency	8560.0 MHz	---		5010.024 MHz	---

The experiment was held on December 16th – 17th. A frequent update on the target ephemeris had been performed during the previous two weeks, in order to obtain the best accuracy on the asteroid position and the doppler shift of the expected echo. As the target was approaching the Earth, and both its coordinates and apparent radial velocity were quickly varying, it was essential to update these quantities every 5 minutes to perform the best pointing and an initial correct tuning of the local oscillators – to keep the possible echo within the narrow band.
During the experiment the incoming signal was analysed in real time using two different spectrometers tuned on the RCP only: *Mspec0* and *SerendipIV* [2,3].
Mspec0 was at first used as a real time previewer, in the following configuration: 0.5 MHz of bandwidth and 65536 channels, a sampling rate of 1.1 10^6 s^{-1} chosen in order to satisfy the Nyquist criteria, giving a spectral resolution of 8.3 Hz per channel. At the same time the SerendipIV realtime system was supposed to give immediate information about the signal frequency drifting, as its 15 MHz bandwidth used with 25 million channels provides a resolution of 0.6 Hz per channel (corresponding to a velocity resolution of 21 mm/s). The LCP CW transmission from Goldstone started at 22:30UT and stopped at 02:45UT of the following day. The echo was instantaneously detected by both the instruments.
An essential test was performed to make the echo identification certain: off-source acquisitions did not show any signal.
The following step was to achieve the spectra using on-off cycles calibrated by means of an injected mark. Contemporarily, the SerendipIV spectrometer recorded the signal rapid frequency drifting (about 167 Hz per minute), as shown in Fig.1.

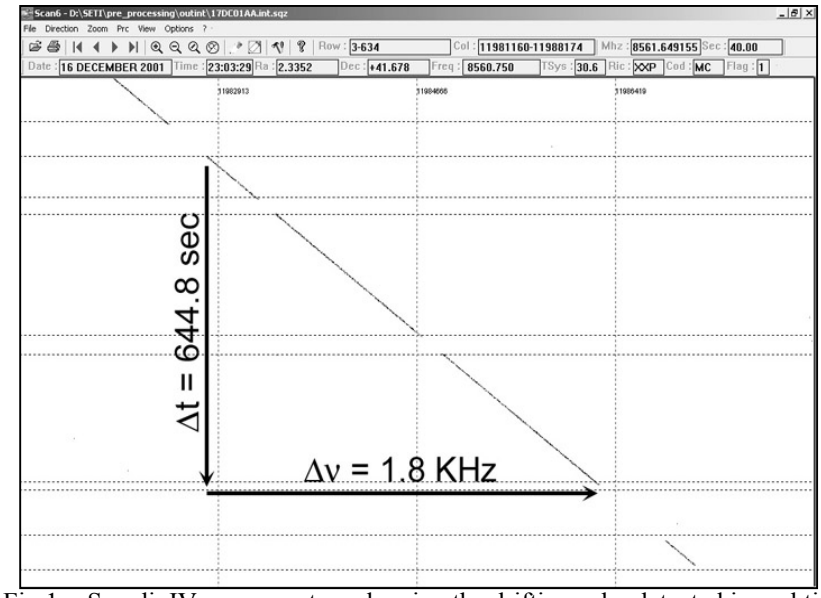

Fig.1 - SeredipIV screencapture showing the drifting echo detected in real time.

Results

A first off-line analysis of the acquired data was carried out focusing on a single cycle. The four blocks composing the cycle provide the spectra given in Fig.2. Measures of the line parameters are summed up in Table 2. The average values allowed an estimation of the received power of 7 10^{-20} W, yielding an observed RCP radar cross section of about 4.02 10^4 m^2, with an uncertainty of 10% on the antenna temperatures due to the error on the calibration mark value.

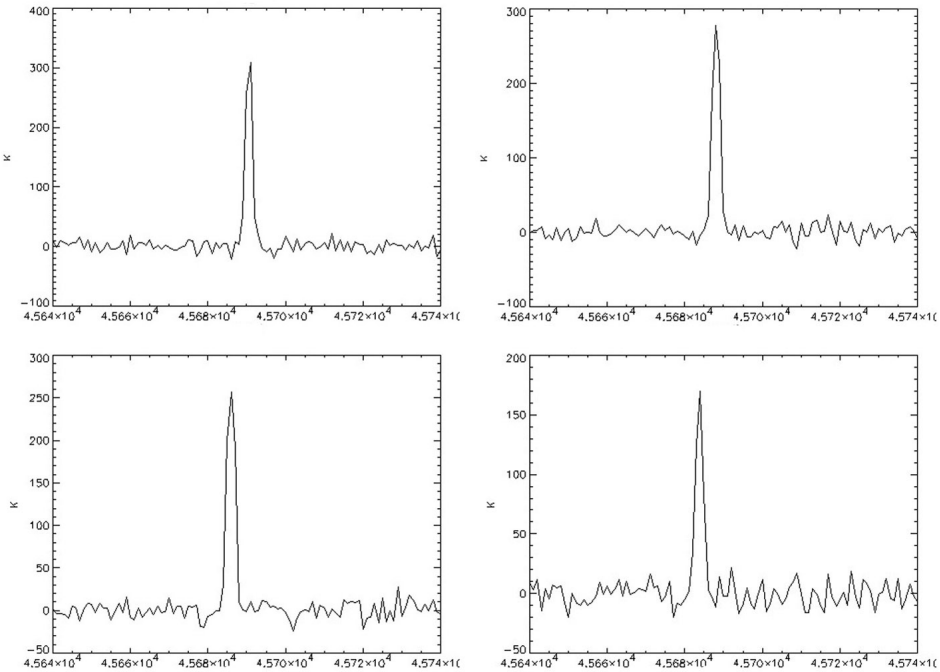

Fig.2 – Spectra resulting from four on-off blocks.

Table 2 – Line parameters

	T peak (K)	Peak channel (interp.)	FWHM (Hz)
Block #1	353	45690.583	14.814
Block #2	298	45688.106	20.161
Block #3	277	45685.957	20.273
Block #4	175	45683.788	19.026

CONCLUSIONS

This successful experiment paves the way to an Italian consortium aimed at using the existing and future radar facilities, in the framework of an international planetary radar programme.

ACKNOWLEDGEMENTS

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