This year the planetary studies group at the Observatory has been joined by two new staff members, Ellen Howell and Jean-Luc Margot, bringing its total number to six. Most of the group combine their research activities with other obligations to the observatory’s operations, but for the first time in many years the Observatory has a significantly sized group in planetary studies. Ellen, who is supported under her own grant from NASA’s planetary astronomy program, is interested in asteroidal compositions derived from optical/infrared spectroscopy and her work complements the radar observations of asteroids made at the observatory. Jean-Luc’s current interests are in innovative techniques for imaging asteroids and other solar system bodies with radar.

Just prior to Hurricane Georges striking Puerto Rico one year ago, the S-band transmitter’s high voltage cable from the power supply on the ground to the transmitter’s final amplifier in the Dome suffered a catastrophic failure. These cables are very specialized and it was not until March that a temporary replacement cable was obtained that allowed the planetary radar system to resume operation. Since then, the transmitter has worked very reliably under the care of Tony Crespo. The only problem was the loss in September of a filament transformer in the socket tank of one of the transmitter’s amplifying klystrons resulting in half power operation until it was repaired in mid-October.

Significant improvements have been made, primarily by Phil Perillat, over the past few months in the system control and data acquisition software. Included are new capabilities for delay-Doppler observations of very nearby asteroids and comets with round-trip light travel times as small as 10 seconds, frequency switched CW observations of near earth and mainbelt asteroids, and planetary satellites such as Titan, and delay-Doppler mapping observations of Mercury and Venus including interleaved pointing measurements. Under development is software for pseudo-infinite length phase coded observations of overspread targets such as the Galilean satellites of Jupiter, and for frequency switched delay-Doppler observations of the rings of Saturn. Most of these observations require integrated control of the transmitter, the transmitter’s modulation, the Dome’s rotary floor, antenna pointing, data acquisition, Doppler correction, and, eventually, the telescope’s tie down system.

Data acquisition hardware for radar astronomy is being significantly enhanced by a new 20 MHz bandwidth direct sampling system being developed by Margot. A single channel prototype of the system has been taken to both the Madrid and Goldstone 70 m NASA/DSN antennas to record data for tests of high resolution radar interferometric delay-Doppler mapping observations of asteroids. In these experiments, Arecibo transmits and the echo is received by both Arecibo and the Madrid or Goldstone antenna.

![Image of Mercury](https://example.com/mercury_image.png)

**Fig. 19:** The 1.5 km resolution radar image of the north polar region of Mercury
The interferometric fringe phase is an additional input to the modeling of the asteroid's size, shape and surface structure.

Since May there have been observations of Mercury, Venus, the three icy Galilean satellites of Jupiter and a number of both near earth and main belt asteroids. In July, John Harmon (NAIC) and Martin Slade (JPL) continued their investigation of the probable water ice deposits at the poles of Mercury using the 2.38 GHz radar system with a range resolution of about 1.5 km. At this resolution the structure of the individual deposits on the shadowed floors of the larger impact craters is very clearly delineated and, somewhat unexpectedly, there appear to be ice deposits in small craters at significant distances from the poles (Figure 19). Greg Black (NRAO), Don Campbell (NAIC) and Harmon also detected the ice deposits with the 430 MHz radar system. Modeling based on the 13 and 70 cm results will be used to derive constraints on the depth and other properties of the ice.

In August Campbell, Bruce Campbell (National Air and Space Museum), Margot, John Chandler (SAO) and Lynn Carter (Cornell) made the first mapping observations of Venus since prior to the Magellan mission to that planet. These will complement the Magellan results by providing information on the polarization properties of the reflected signal. A major puzzle from previous radar and radio thermal observations of Venus is the low emissivity and, hence, high reflectivity of terrains at high altitudes. The polarization results may help to explain this phenomenon. A linearly polarized component in the reflected signal would indicate penetration of the radar wave into the surface, implying that sub-surface scattering probably plays a role in causing the high reflectivities. The absence of a linear component may indicate that the echo results from pure surface reflection, implying that the surface material has an intrinsically high reflectivity. A careful search will also be made for any surface changes since the Magellan mission related to volcanic activity, aeolian processes or landslides.

The study of asteroids, both those that come close to the earth (NEOs) and those in the main belt, is a major objective with the upgraded S-band radar system. Since April, successful observations have been made of six main-belt asteroids and six NEOs. Four of the NEOs were only discovered shortly before their close approaches to the earth and were observed under proposals for targets of opportunity. This worked well, with other observers displaying considerable flexibility in rearranging their observations to allow for the radar work.

C. Magri (Maine), M. Nolan (NAIC), S. Ostro, J. Giogini (JPL), R. Hudson (WSU) and D. Yeomans (JPL) carried out CW and ranging observations of the main belt asteroids 41 Daphne, 105 Artemis, 198 Ampella, 85 Io, 219 Thetis, and 216 Kleopatra in the continuing program for measuring the radio wave scattering properties of main belt objects. In June, Ostro, L. Benner (JPL), Campbell, Giogini, Hudson, Nolan and Yeomans obtained the highest resolution delay-Doppler imaging of an asteroid to date, 15 m, for the NEO 6489 Golevka. Under a separate proposal, Margot and Nolan attempted radar interferometric delay-Doppler imaging observations utilizing the Arecibo and Madrid antennas. A detection of Golevka was made with Madrid but the signal-to-noise ratio was not high enough to obtain fringes.

In May of this year the NEO 1999 JM8 was recovered and plans made for radar observations at both Arecibo and Goldstone. JM8 passed within about 9 million kilometers of the earth and, at an estimated size of approximately 3 km provided an excellent opportunity for high resolution imaging observa-
tions. At Arecibo these took place over the first 9 days of August and involved the same group of observers as for the Golevka observations. Figure 20 shows the 15 m resolution delay-Doppler image obtained on August 5. This image, when combined with others made at different rotational longitudes, will provide a very detailed three dimensional model of JM8.