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Discovery of two additional Jovian irregulars.

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Abstract

In September 2010 Jupiter and Uranus passed each other on the sky. This allowed our team to easily recover many Jovian and Uranian irregular satellites with uncertain orbits.

In addition to the planned recoveries, our observations revealed two previously undetected Jovian irregular satellites. Jacobson et al. [3] and Veillet et al. [7] provided the discovery data for S/2010 J 1 and S/2010 J 2, respectively. Follow up observations in October 2010 to January 2011 indicates that these are $\sim$ 1 km objects on bound retrograde orbits. However, the fitted orbits are still too uncertain to determine which, if any, satellite group these additional satellites belong to [2]. We will obtain additional observations in July and August 2011, allowing us to present accurate orbital and grouping information.

1. Introduction

In September 2010, the unusual event occurred that Jupiter and Uranus were close to each other on the sky (within 1.5 deg) at opposition. This caused their Hill-spheres to overlap (see Fig. 1). This opportunity was used by our team to recover many Jovian and Uranian irregular satellites with uncertain orbits, during a single observing run where both planets were available.

2. Recoveries

The Uranian satellites Margaret and Ferdinand were of particular interest, as they had not been observed for several years and were in danger of being lost (see abstract by Gladman et al, at this meeting). These 25th magnitude satellites were recovered using observations at the Palomar 200-inch Hale telescope. Other high-uncertainty Jovian irregulars were also targeted.

Additional recoveries were performed through a 3 hour series of 260 s images using the Canada-France-Hawaii Telescope (CFHT) MegaCam camera, which has a 1 deg^2 field of view. This gave us 60 images, a total of 8400 s exposure of the field, penetrating both Hill spheres, see Fig. 1.

The Jovians recovered in our September Palomar and CFHT observations were Kore, Kale, Orthosie, Hermippe, Erinome, Eurydome, Harpalykke, Iocaste and S/2003 J 16. The Uranians Ferdinand, Margaret, Caliban and Prospero were recovered.

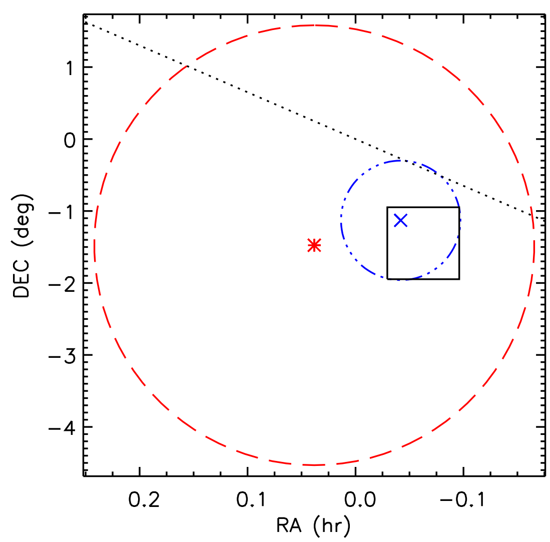

Figure 1: Plot of the positions of Jupiter and Uranus, as seen on the sky on the 8th of September UT, 2010. The red star is Jupiter, and the blue cross is Uranus. The red dashed circle marks 60% of Jupiter's Hill Sphere radius, the dash-dotted blue circle marks 60% of Uranus' Hill Sphere radius (60% of the full Hill radius is used, as orbits are unstable on long timescales if they bring the satellites outside of this). The black box illustrates the field targeted by our deep CFHT observations. The Palomar fields (not shown) were distributed all around this diagram for targeted recoveries. The dotted gray line is the ecliptic.

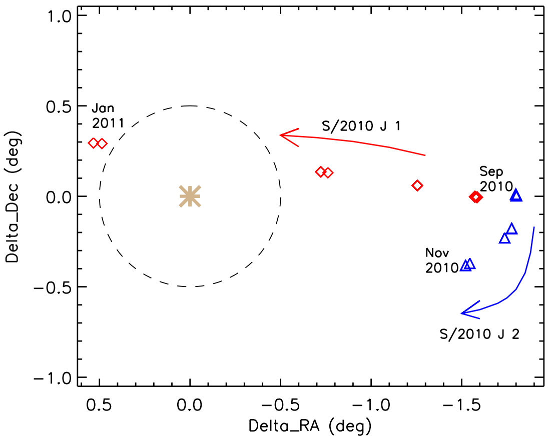

Figure 2: Plot of the positions for the two newly discovered Jovians, in Joviocentic space. The red diamonds are the relative astrometry for S/2010 J 1, the blue triangles are for S/2010 J 2, the tan star is Jupiter. The dashed circle is 0.5 deg around Jupiter in which observations are difficult due to glare from the planet.

3. Discoveries

The reduction of the Palomar observations revealed a previously undiscovered Jovian satellite, of magnitude $m_r \sim 23.6$. The CFHT observations confirmed this discovery, and also revealed yet another previously unknown Jovian satellite of magnitude $m_r \sim 24.2$. These two satellites have since been observed in ongoing tracking from CFHT, allowing us to determine with certainty that these are both retrograde irregular satellites, on bound orbits. Their motion, in jovicentric space, can be seen in Fig. 2. Additional observations in 2011 will be obtained, giving us a full year of arc and enabling accurate orbital determinations.

We believe that these two newfound objects, while near the limits of previous surveys, may have been in front of or behind Jupiter at the time of previous surveys and thus hidden in the glare from the planet, obscuring them from detection. Our future improved determinations of their orbits should verify this hypothesis.

The discoveries of these two Jovian satellites are in the process of IAU publication [3, 7], with designations S/2010 J 1 and S/2010 J 2, respectively.

4. Deep search of the data

Because satellite positions on the sky change at a rate of arcseconds per hour, simple stacking of images will not increase the signal to noise for the satellites. Rather, they will be trail, diluting the signal of faint objects. Instead, a shift and stacking method known as pencil-beaming [1], can be used to reveal objects too faint to see in the individual pictures. The images are shifted at a grid of rates and angles close to the motion of the parent planet, and then stacked. A satellite will show up as a point, identical to the average point spread function, in the images when the rate is that of the satellite's motion, whereas stars in the field are smeared out. It is then fairly easy to visually search such stacked images for satellites.

The 3 hours of CFHT September data are currently being searched using this pencil-beam method, at both the Uranian and Jovian rate of motion. This search will have a depth of $m_r \sim 26$. This is similar to earlier search depths of the Uranian Hill sphere [4, 6], but significantly deeper than the Jupiter Hill sphere has been searched [5].

For the Uranian system, this will give us an additional recovery observation of Margaret, Ferdinand and several others of the known Uranian satellites. Discovering another Uranian is possible, but unlikely. For the Jovian system, we expect to detect many unknown satellites. However, tracking of these faint objects near Jupiter would require a tremendous amount of observing time, so these detections will be used for an improved understanding of the size distribution of the Jovian small irregular satellites.

References

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