Attempts at planetary imaging:

Jupiter, the Moon and Saturn

During the Spring semester of 2004 by

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(under supervision of Dr. Tibor Torma)

Generalities

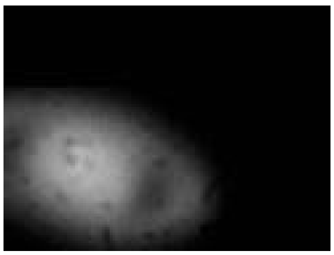
We attempted to take images of Saturn, Jupiter and the Moon to investigate the quality attainable with the instruments we now have and to identify the factors that might be improved upon.

As a basic reference, we took a set of images of Jupiter on April 6 (A. Lanaux &C. Clayton) from the little dome of Kennon Observatory with the 12 inch Meade SCT at f/5 (i.e. f=120 cm). The setup was Telescope → JMI focuser → 0.63 focal reducer → AO7 (disabled) → CFW8 filter wheel → ST7 camera. We took the shortest exposure times we had, t=0.12 sec with IR blocking R,G,B filters. The images have been color composed with CCDoops and Photoshop 7.0.

The relatively wide field of the ST7 allows to image the planet and its moons simulataneously. Images were aligned using the moons, and the slow download time of the camera resulted in a visible shift in the colors (due to the orbital motion of the moons).

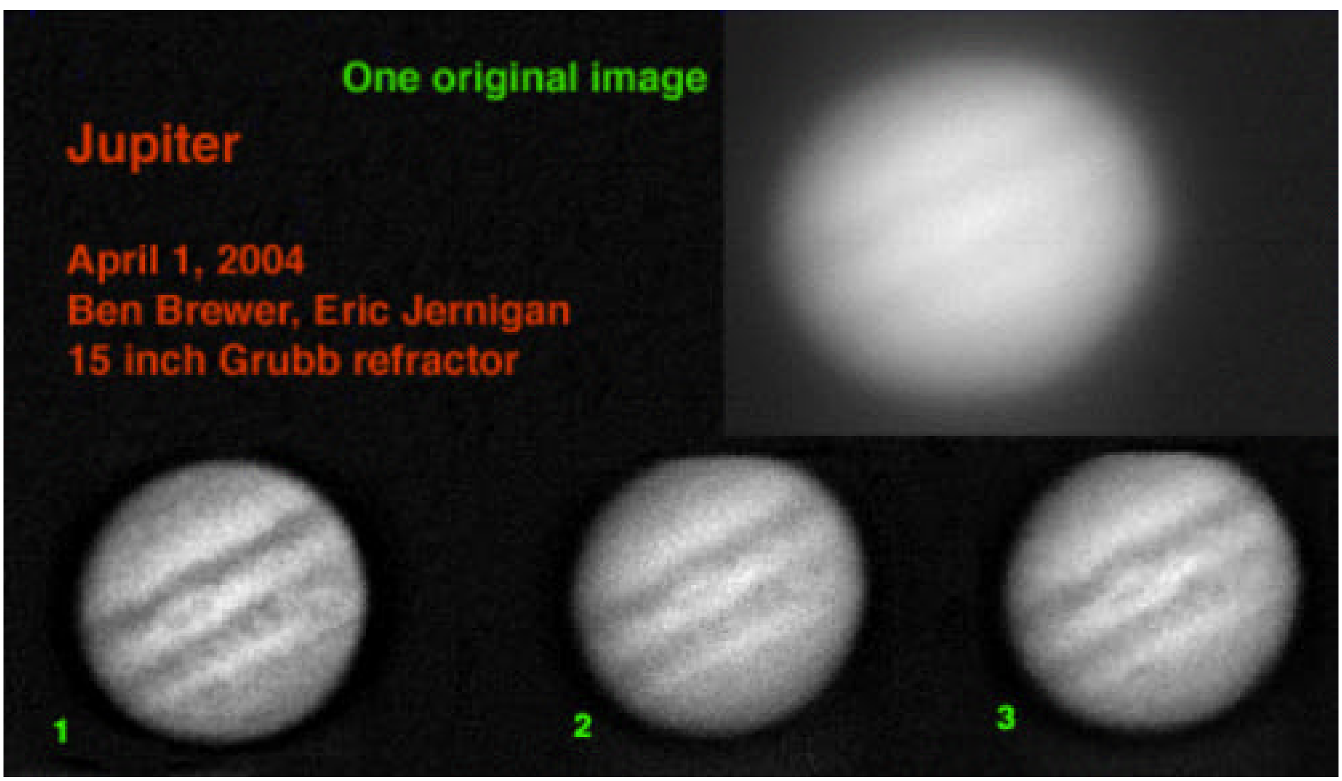
Jupiter

The 15 inch refractor in the big dome seems promising when used with a cooled CCD camera that can take as short exposures as t=0.01 sec. We found, however, that the advantages of using a refractor and this camera cannot be realized without the following ingredients simulataneously in place: (1) much improved tracking, (2) crosshair in the finder telescope, (3) a computer-controlled filter wheel, (4) a motorized focuser. In fact the quality of tracking is so bad that it makes even pointing almost impossible. Without reasonable tracking it is impossible even to assess whether a cooled CCD with filters gives better results than a webcam or a digital camera.



On March 16 (B. Brewer, E. Jerningan) we took images of Saturn in direct focus (at f/12). It proved impossible to achieve focus without the use of a Barlow lens.

On April 1 (B. Brewer, E. Jerningan) we used a Teleview Barlow lens to add back focus. The focal length was increased to f=10 m (i.e. f/26), which produces a pixel size of 0.125 as x 0.125 as. This pixes size provides ideal sampling of the diffraction-limited resolution of the refractor (0.25 as), and still gives a reasonable signal/noise ration of $\Delta S/N$ = 7.5 (here ΔS is the difference



between the dark and the bright bands on the surface of Jupiter). The camera was cooled to T= -10 C.

Due to Jupiter's fast rotation, the central meridian is moving with a speed of 0.2 as/min. If we want to avoid smearing due to rotation, we need to use images taken within sessions that are at most 1.5 min long. Given that the download speed of the ST-5C camera is 16 images per minute, there is little chance to find a suitable pair or triplet of still-seeing color images, even with a motorized filter wheel. A CCD camera with USB download would be definitely helpful for that purpose, provided the other necessary ingredients mentioned above are given (in addition to the existence of instants with 0.3 as seeing). If all that is realized, the image quality should be much better than what is achievable with webcams or digital cameras.

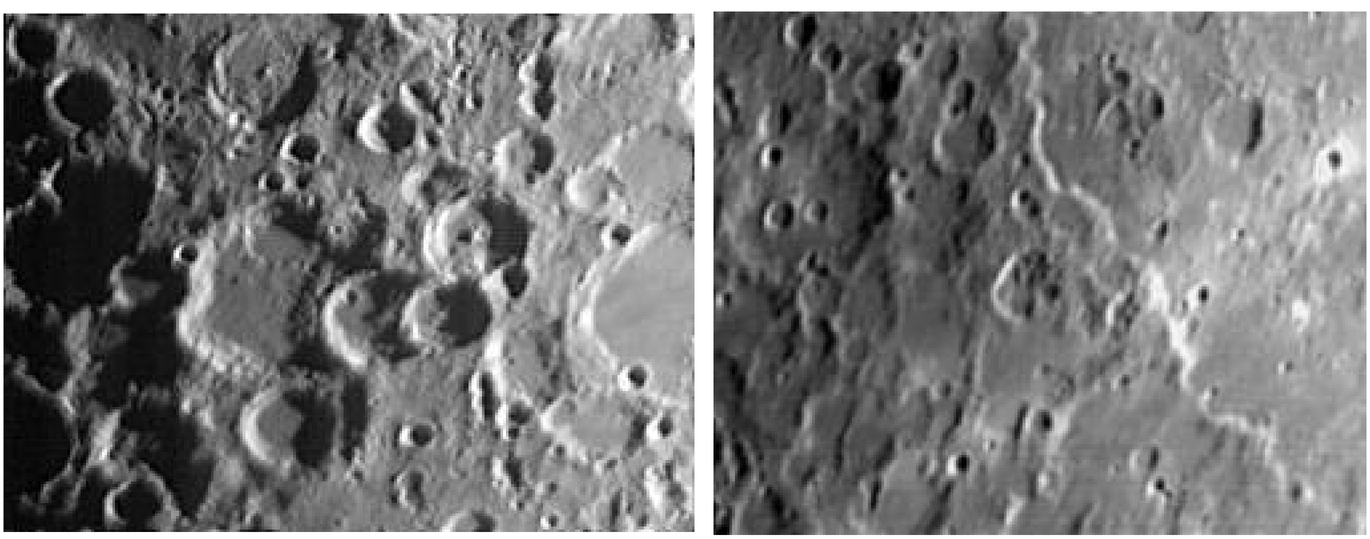
The images were processed with CCDoops, CCDsoft, Keith's image stacker, and Photoshop 7.0. Because of the inaccuracy of our manual focusing we had to use unmask sharpening very heavily. Image No. 1 is a stack of the six bext images out of 14 (within one minute, smearing less than 0.3 as). The smallest detail that is not a sharpening artifact is about 0.3 as in size). Image no. 2 is a stack of the best ten of 40 images, and no. 3 is a stack of 5 of a set of 10 images.

On April 27 (K. Pittman) we used a Meade 12 inch SCT on a pier in the parking lot next to Kennon Observatory. Probably due to the heat absorbed in the concrete of the parking lot, seeing was not great (we estimated it around 2-3 as). Also, we do not expect that this type of seeing would "freeze" for any short time as seeing originating at high in the atmosphere does. We clearly observed on the images (all taken with t=0.01 sec exposure time) that features that are sharp and clear on each image are located at slightly different places in different images (after aligning one such feature). The result is that combining a stack of images gives little improvement over only using the only one best image. We think that the solution is to move to a place where this ground-related component of the seeing is small.

The images were taken with the 12 inch Meade SCT at f/10 (i.e. f=3 m). The setup was Telescope → JMI focuser → screw-on filters → ST5 camera. We took the short exposure times, t=0.01 sec with IR blocking plus Orion R,G,B filters. The images have been color composed with CCDoops, Keith's image stacker and Photoshop 7.0.

Because changing the filters by hand took four minutes, smearing was unovoidable. The pixel size is 0.7 as x 0.7 as, and we found a signal/noise ration of ΔS/N = 20 (defined above). The camera was cooled to T= -10 C.

Because of the smearing that is inevitable when three color components are taken with a time interval, we used only the red and blue images, each of which is a stack of 5 chosen from 10 filtered images. The green channel was simply replaced by the average of the blue and red channels, thus avoiding smearing, but giving a somewhat distorted color balance. The difference between the two images is that on the color components of the one on the left a strong unsharp masking was applied, followed by noise removal, while the right picture underwent unsharp masking only after color composition.



The Moon

On April 27 (K. Pittman) we used the same equipment setup to also picture the Moon. The difference between the otherwise sharp images clearly indicates that the large component of the seeing had time scale much larger than the exposure time of 10 msec. The images shown are a result of composing stacks of 5 best images out of a hundred each.