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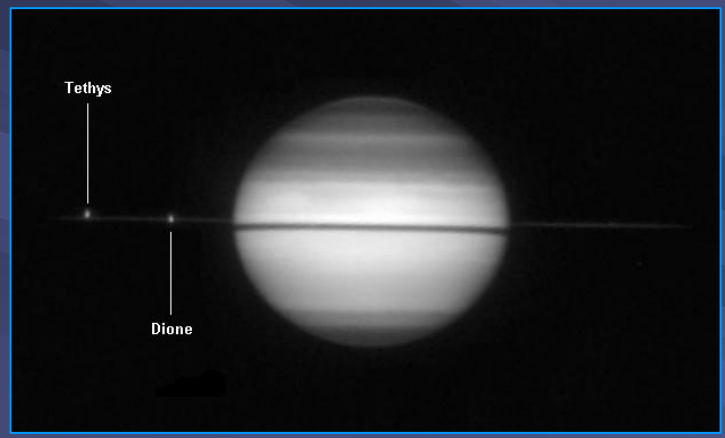
The ALPO Saturn Section

Current Programs, Recent Observations, and the 2009 Edgewise Orientation of the Rings



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Importance of Planetary Observations by Amateurs

- Freedom to observe solar system objects for extended periods of time, unlike many professionals who often face time and funding constraints.
- Systematic, standardized observations provide a long-term, continuous record of changing aspects of solar system objects.
- Provide a vital “missing link” through comprehensive observational coverage, since poor positioning of spacecraft cameras, or unfavorable solar illumination, sometimes gave professionals incomplete views or isolated “snapshots” in time of solar system objects.
- Earth-based monitoring by amateurs of changing atmospheric features on planets like Saturn have often helped professionals select targets for high-resolution spacecraft imaging.
- In addition to systematic, simultaneous visual observations, some observers have produced remarkably detailed images of planetary phenomena in different wavelengths of light with CCD cameras and webcams, which are highly useful to the professional community.
- The ALPO serves *to encourage and coordinate regular, systematic investigations of the Sun, principal planets, and other members of our solar system with instrumentation readily available to amateur astronomers.*

Suggested Instrumentation for Observing Saturn

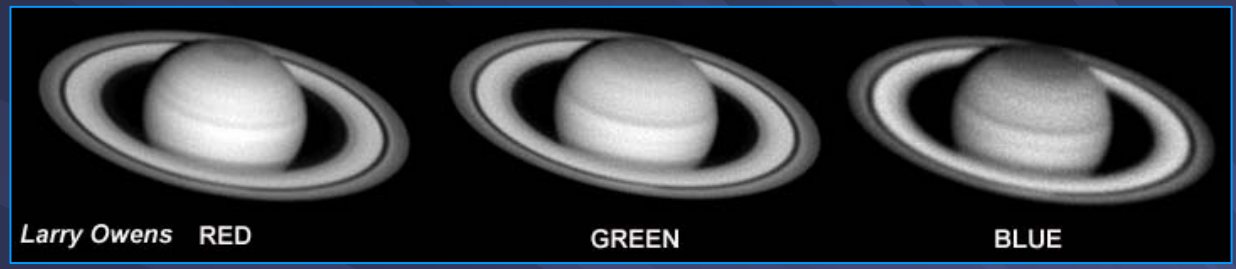
- Telescopes should have excellent, precisely-aligned optics, with apertures of at least 10.2 cm (4.0 in) for refractors and 15.2 cm (6.0 in) for Newtonian reflectors and catadioptrics (although remarkable work has been done with much smaller apertures).
- A sturdy equatorial mount with slow-motion controls and a clock-drive is highly desired. “Go-To” mounts are not essential for most planetary work (i.e., save the money and spend it on more aperture).
- Color filters (Wratten or Schott) of known wavelength transmission, plus a variable-density polarizer. For achromatic refractors, use a filter that suppresses the secondary spectrum.
- *Astronomical Almanac* or access to a suitable printed or electronic ephemeris.
- Digital imaging equipment (e.g., webcam, digital or video camera, or CCD imager). IR blocking filters are suggested.
- A laptop computer with applicable software for capturing, stacking, manipulation, and processing of images of Saturn.

Keys to Meaningful Results

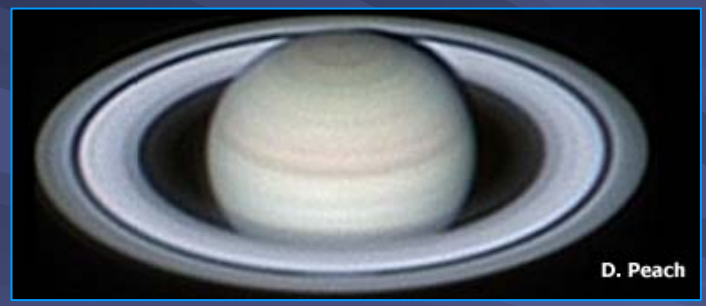
- Maintain accurate records of your observations, and *always* include basic information such as image orientation, date and time (UT), location of the observing site, telescope, magnifications, filters, etc.
- Don't forget to make estimates of the seeing and transparency conditions using standard ALPO criteria.
- Send *originals* of all data to the ALPO Saturn Section for analysis periodically during an apparition. Electronic submittal of images and scanned drawings is strongly encouraged.
- Form the habit of making regular *systematic observations* to improve continuity in the observational data. Widely-spaced observations in time, or those that are poorly-planned, usually have minimal scientific value.
- Strive for *simultaneous observations* (i.e., independent, systematic studies by two or more observers using similar methods and equipment on the same date and at the same time).
- Start observing early in an apparition when Saturn has just emerged from the solar glare, continue through opposition, and persevere until the planet again nears conjunction with the Sun.

Some Achievements by ALPO Saturn Observers

- Visual observations show that distinct belts & zones are not just occasionally seen on Saturn, and discrete global & ring phenomena is more obvious with color filters and a variable-density polarizer.



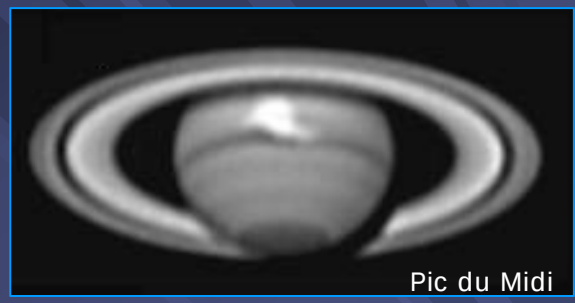
- Cassini's and Encke's divisions are not the only such “gaps” in Saturn’s rings (e.g., several "intensity minima" in the rings were routinely seen by amateurs prior to the *Voyager* missions).



- Ring C can be seen as well as imaged at the ansae and in front of the Saturn’s globe with small-to-moderate apertures.

- Analysis of long-term observations of recurring dark features and bright spots have revealed a pattern to atmospheric outbursts on Saturn.

The Great White Spot of 1990



- Analysis of CM data collected for long-enduring spots on Saturn suggests a definite variance in the rotation rates of the SEB and NEB.
- Over a Saturnian year (29.5 Earth-years) belt and zone intensity data reveal a subtle seasonal effect on the planet.
- The very tenuous Ring E outside Ring A was seen by amateurs prior to the *Voyager* flybys.
- Amateurs periodically reported dusky radial "spokes" in Ring A and B prior to *Voyager*.

Recent observations of radial ring "spokes"

- The *bicolored aspect of the rings* and curious *azimuthal brightness asymmetries* in Ring A have been seen visually as well as being captured on film and with digital imagers.

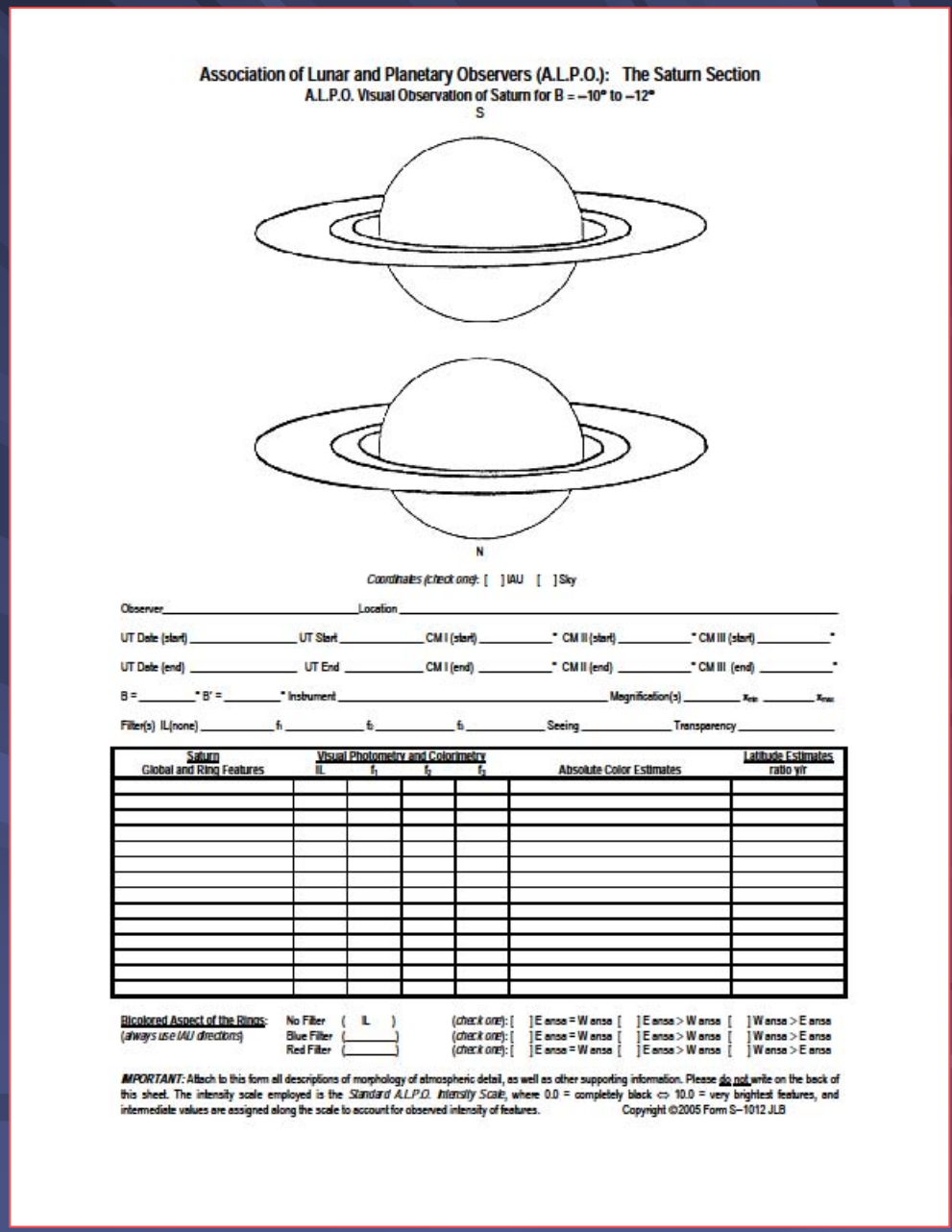
Current ALPO Saturn Observing Programs

- Visual numerical relative intensity estimates of belts, zones, and ring components.
- Full-disc drawings using standard ALPO observing forms.
- Central meridian (CM) transit timings of atmospheric details in belts and zones
- Estimates or measurements of belt and zone latitudes and changes in width.
- Colorimetry and absolute color estimates of globe and ring features.
- Observation of Cassini's, Encke's, and Keeler's divisions plus "intensity minima" in the rings.
- Systematic monitoring the rings for the curious "bicolored aspect" and azimuthal brightness asymmetries around the circumference of Ring A.
- Observations of stellar occultations by Saturn's globe and rings.
- Specialized studies of Saturn during edgewise ring orientations.
- Visual observations and magnitude estimates of Saturn's satellites.
- Multi-color photometry and spectroscopy of Titan to confirm a rotational light curve variation of 7% at 940nm noticed since 1990-93.
- Regular digital imaging of Saturn and its satellites in addition to regular visual observations.

Sample ALPO Saturn Drawing Blank

Although regular imaging of Saturn is extremely worthwhile, observers <u>should</u> <u>not</u> <u>neglect</u> the fundamental process of sketching Saturn as well as making routine visual numerical relative intensity estimates.

Such visual observations are badly needed in forthcoming apparitions!



Association of Lunar and Planetary Observers (A.L.P.O.): The Saturn Section

A.L.P.O. Visual Observation of Saturn for B = –10° to –12°

S

N

Coordinates (check one): [ ] IAU [ ] Sky

Observer _____ Location _____

UT Date (start) _____ UT Start _____ CM I (start) _____° CM II (start) _____° CM III (start) _____°

UT Date (end) _____ UT End _____ CM I (end) _____° CM II (end) _____° CM III (end) _____°

B = _____° B' = _____° Instrument _____ Magnification(s) _____ $\times_{min}$ _____ $\times_{max}$

Filter(s) IL(none) _____ f_1 _____ f_2 _____ f_3 _____ Seeing _____ Transparency _____

Saturn Global and Ring Features	Visual Photometry and Colorimetry IL	f_1	f_2	f_3	Absolute Color Estimates	Latitude Estimates ratio y/r

Bicolored Aspect of the Rings: (*always use IAU directions*)

No Filter (IL) (*check one*): [ ] E ansa = W ansa [ ] E ansa > W ansa [ ] W ansa > E ansa

Blue Filter (_____) (*check one*): [ ] E ansa = W ansa [ ] E ansa > W ansa [ ] W ansa > E ansa

Red Filter (_____) (*check one*): [ ] E ansa = W ansa [ ] E ansa > W ansa [ ] W ansa > E ansa

IMPORTANT: Attach to this form all descriptions of morphology of atmospheric detail, as well as other supporting information. Please <u>do not</u> write on the back of this sheet. The intensity scale employed is the *Standard A.L.P.O. Intensity Scale*, where 0.0 = completely black <> 10.0 = very brightest features, and intermediate values are assigned along the scale to account for observed intensity of features.

2004-09 Professional-Amateur Cassini Observing Patrol

- The Saturn Pro-Am effort began on April 1, 2004 when *Cassini* started observing the planet at close range, and observers are encouraged to participate in the following projects as the *Cassini* mission continues this apparition and beyond:
  - Using classical broadband filters (Johnson UBVRI system) on telescopes with suggested apertures ≥ 31.8cm (12.5in), observers should image Saturn through a 890nm narrow band methane (CH_4) filter.
  - Observers should image Saturn every possible clear night in search of individual features, their motions and morphology. Resulting data serve as input to the *Cassini* imaging system, thereby suggesting where interesting (large-scale) targets exit.
  - Suspected changes in belt and zone reflectivity (i.e., intensity) and color will be also useful, so *visual observers can play a vital role by making careful visual numerical relative intensity estimates in Integrated Light (no filter) and with color filters of known transmission*.
  - The *Cassini* team will combine ALPO images with data from the *Hubble Space Telescope* and from other professional ground-based observatories.
  - Observations should continue to be submitted right away to the ALPO Saturn Section for immediate dispatch to the *Cassini* team.

Saturnian Geocentric Phenomena in UT

2008-09 Edgewise Apparition

- Conjunction — 2008 Sep 04^{d} UT
- Opposition — 2009 Mar 08^{d}
- *Edgewise Orientation of the Rings* — 2009 Sep 04^{d} *Single passage of Earth thru ring plane S → N (unfavorable since Saturn is just two weeks away from conjunction with the Sun)*
- Conjunction — 2009 Sep 17^{d}

Opposition Data:

Equatorial Diameter Globe	19.6″
Polar Diameter Globe	17.6″
Major Axis of Rings	44.6″
Minor Axis of Rings	2.0″
Visual Magnitude (m_v)	$+0.5m_v$
B (ring tilt)	–2.6º

Saturn is in the constellation Leo this apparition

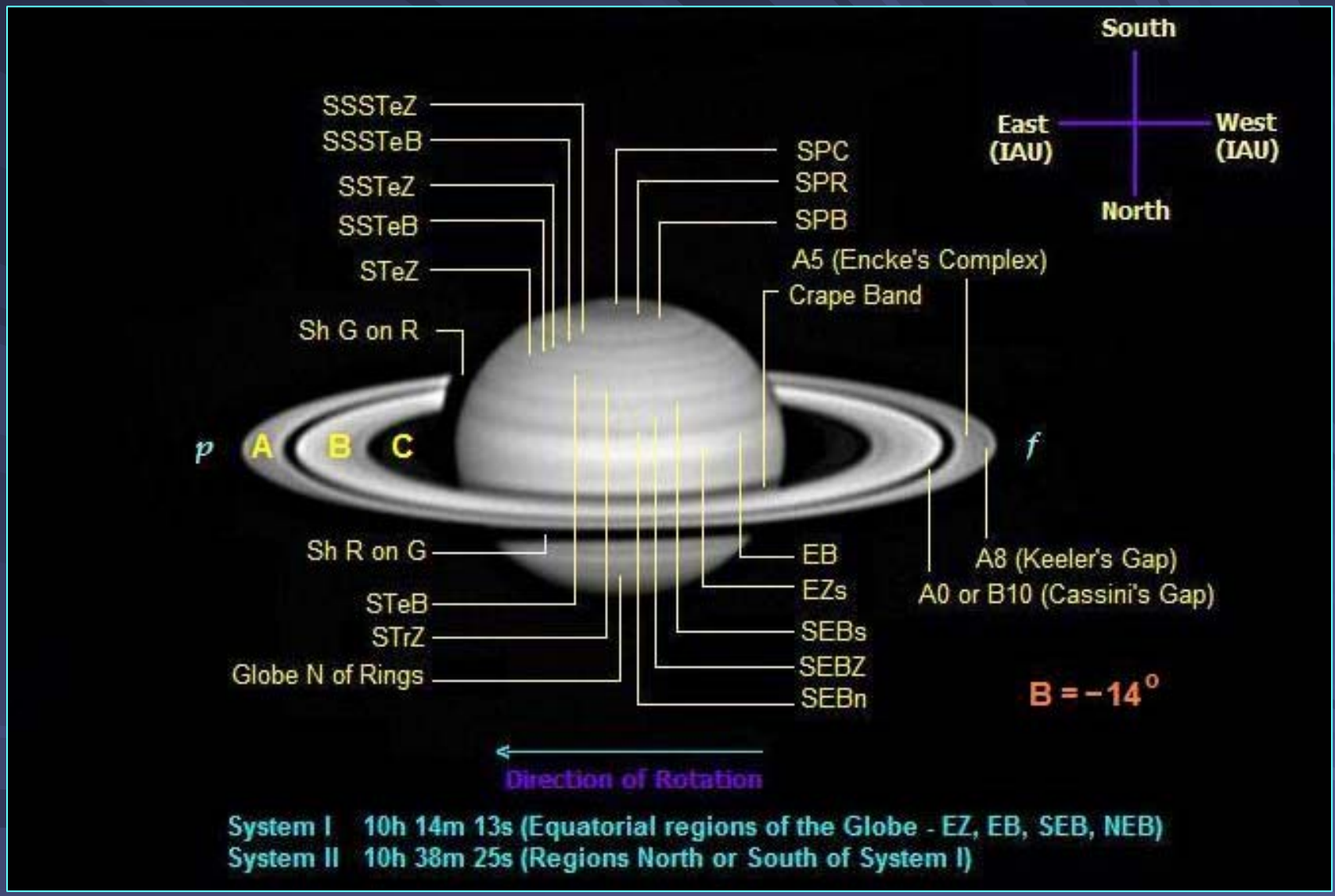
The ring tilt (value of B) ranges between a maximum value of -4.2° (2009 May 13) and 0.0° (2009 September 04)

Next Edgewise Orientation of Saturn's Rings

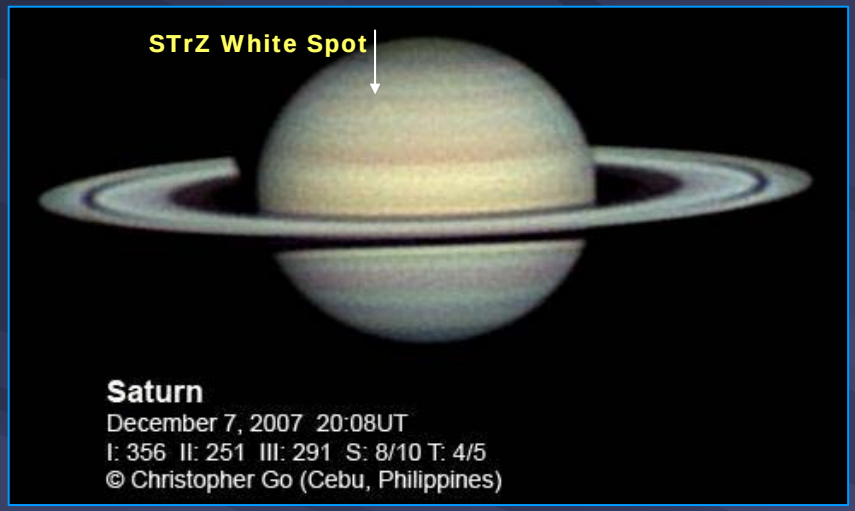
2025 Mar 23 Single passage of Earth thru ring plane N → S (unfavorable since Saturn is again too near conjunction with the Sun)

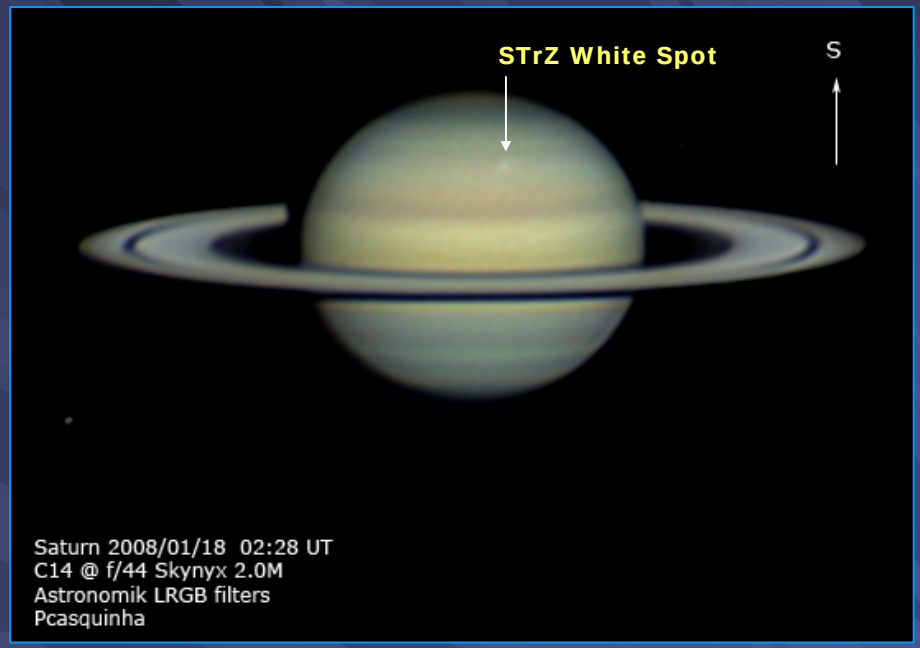
*Unfortunately, observers will have to wait until the **2038-39** apparition to see another triple passage of the Earth through the plane of Saturn's rings as occurred back in 1995-96!*

Standard Nomenclature of Saturn's Globe and Ring Features



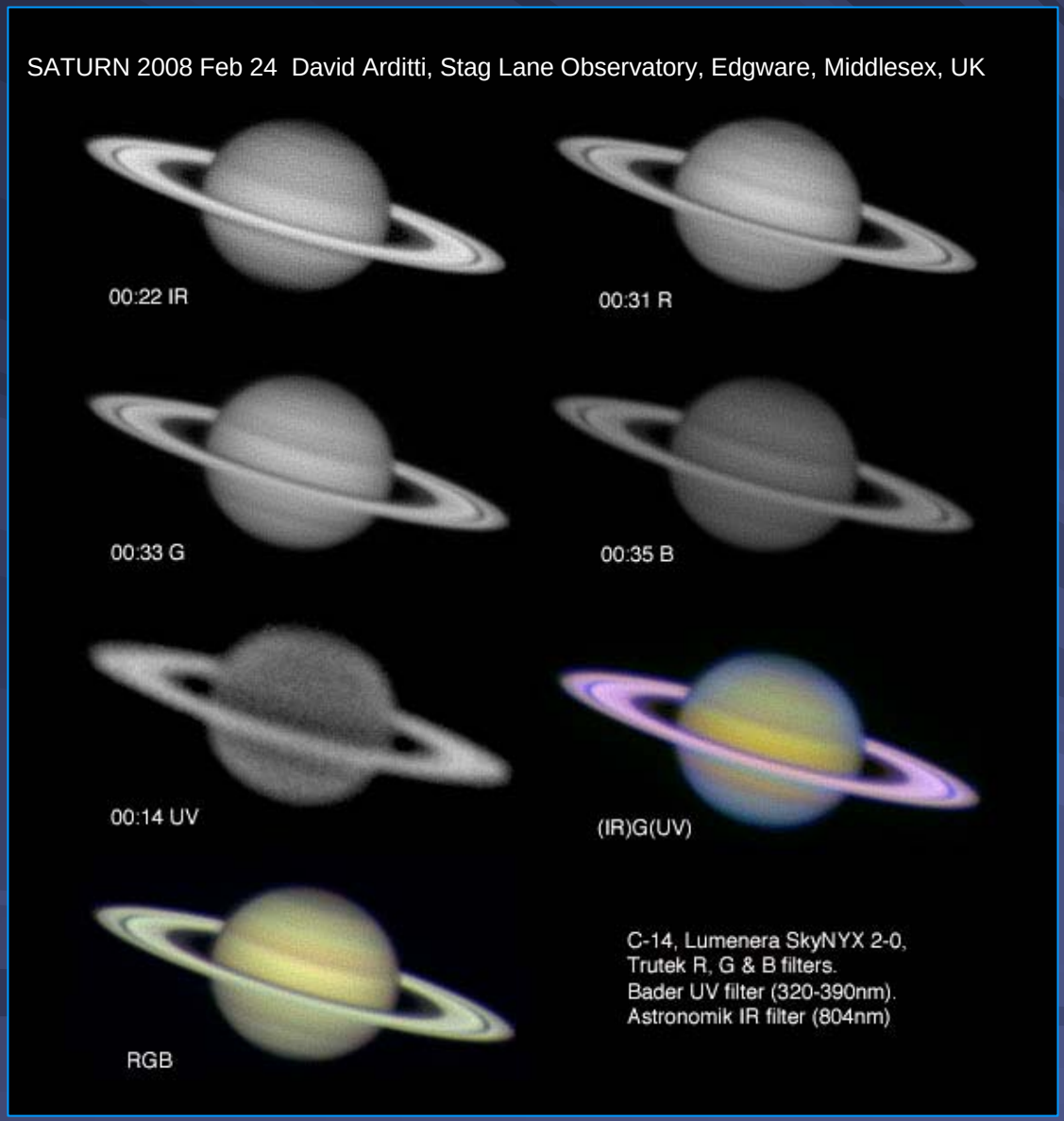
Pre-Opposition Views of Saturn in 2007-08

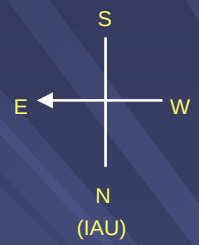




Shadow of the
Globe on the Rings
is toward the East (IAU)
prior to Opposition

Saturn at Opposition in 2007-08





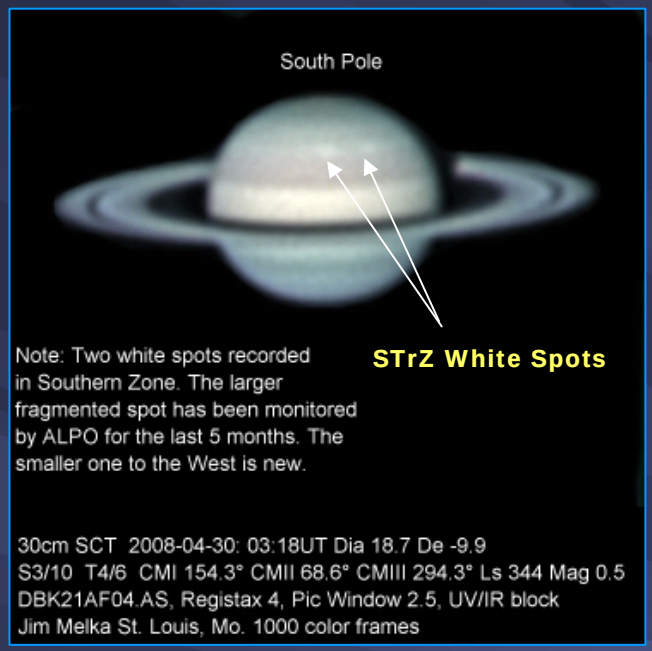
2007-08 Opposition Data:

2008 Feb 24^{d} UT
Eq Dia Globe = 20.0”
Po Dia Globe = 17.8”
Maj Axis Rings = 45.2”
Min Axis Rings = 6.6”
Visual Magn = +0.2
B = -8.4^{o}

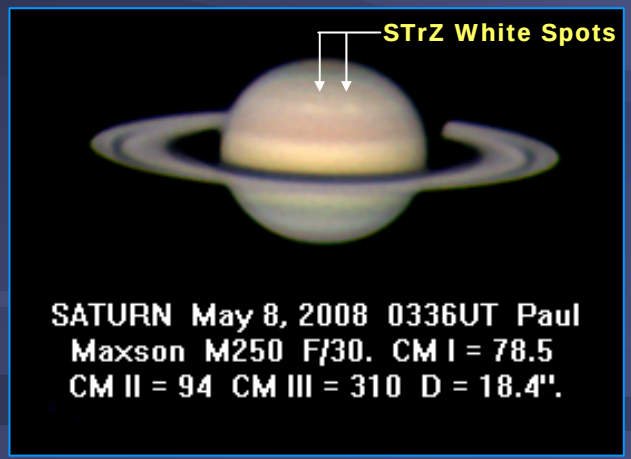
The Seeliger Opposition Effect is an apparent brightening of Saturn's rings during a very short interval near opposition. It is most likely due to coherent back-scattering of μ-sized icy particles in the rings when the phase angle between Sun-Saturn-Earth is <0.3°.

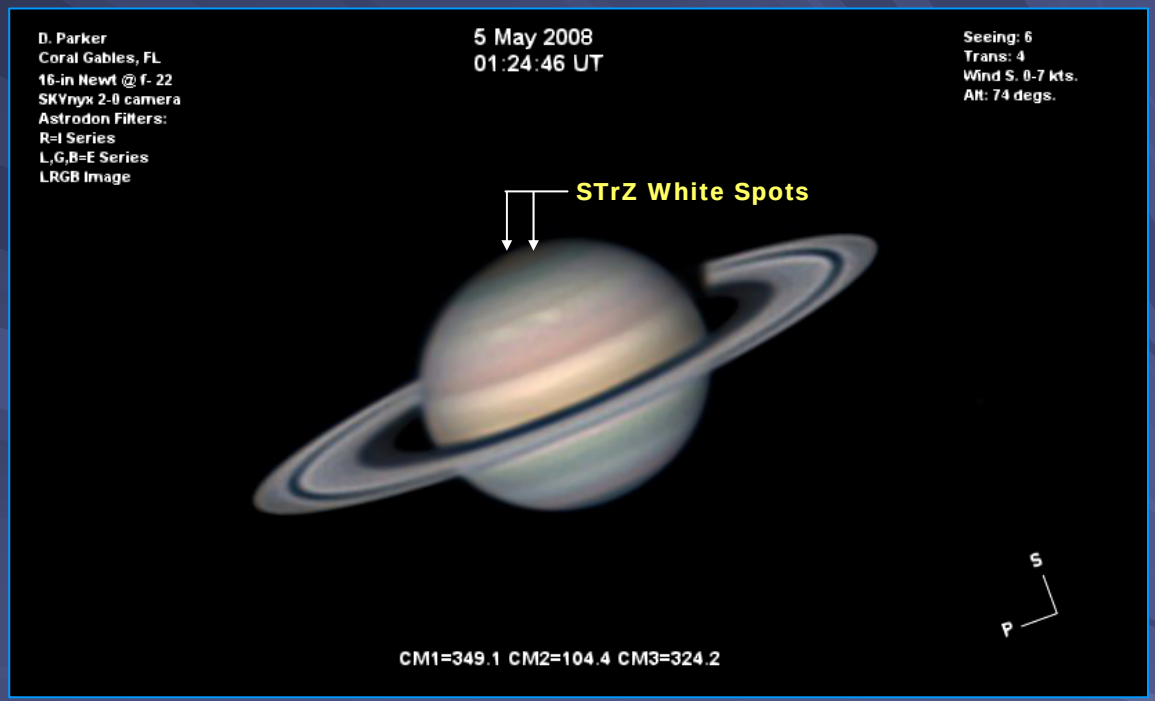
This “opposition spike” was not as strong in 2007-08 because the phase angle was greater.

Post-Opposition Views of Saturn in 2007-08



Shadow of the Globe on the Rings is toward the West (IAU) following Opposition

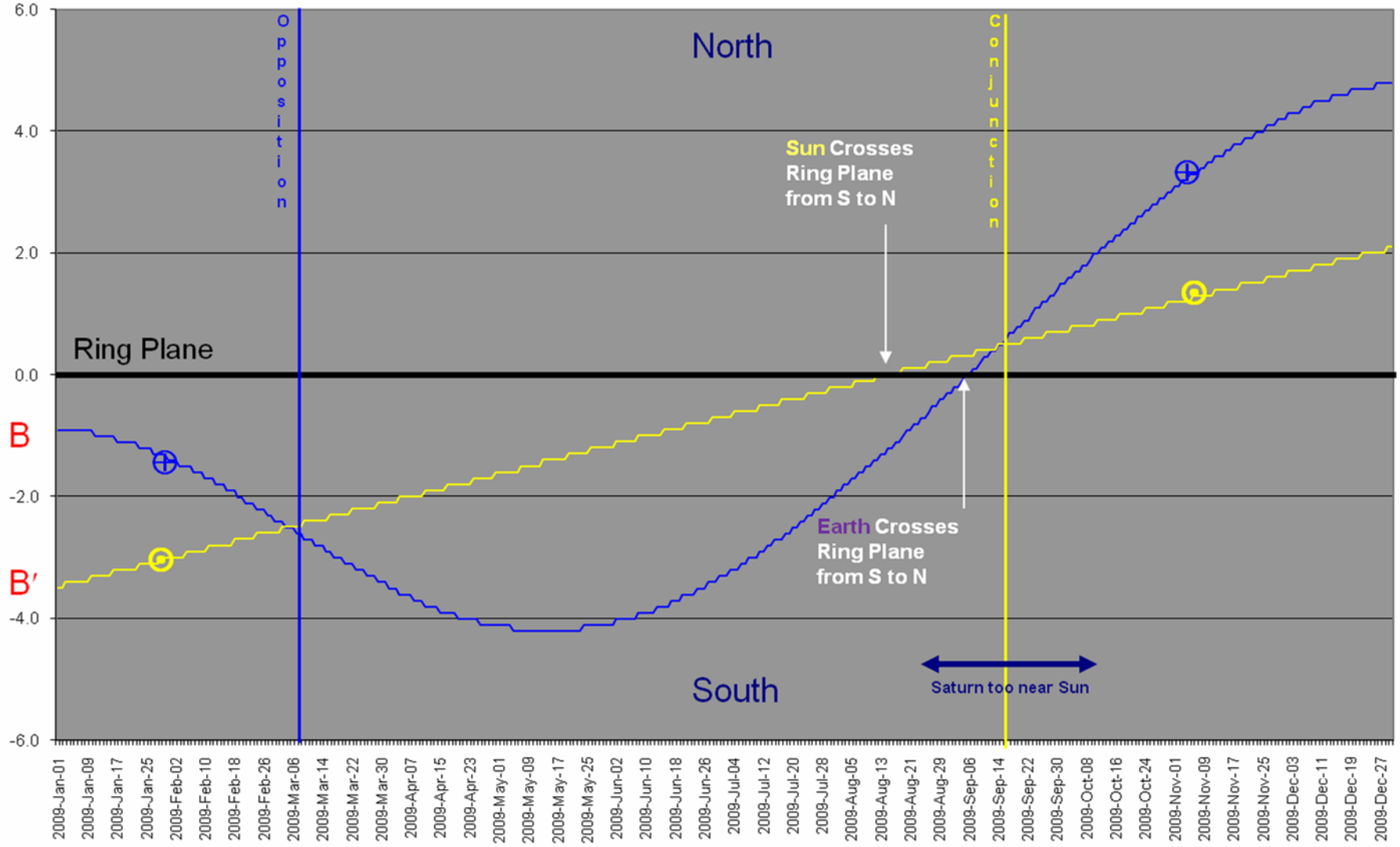




Edgewise Presentations of Saturn's Rings

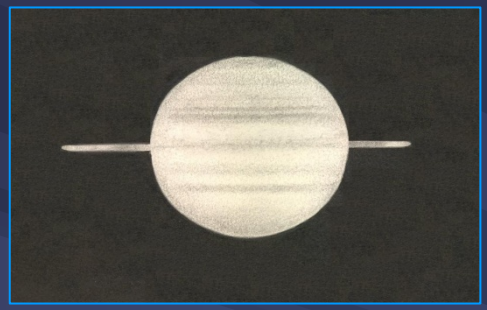
- Saturn's revolution period about the Sun is 29.5^{y}, and the angle of the rings relative to the Sun varies by ±26.7°.
- During this period the intersection of the orbit of the Earth and the plane of the ring system takes place only twice, at intervals of 13.75^{y} and 15.75^{y}.
- Since the rings are so thin (~100m thick) when edge-on, they appear to disappear when viewed with a small telescope.
- The two periods are of unequal length due to Saturn's elliptical orbit about the Sun.
- In the 13.75^{y} period, Saturn's S pole and S ring face are inclined toward Earth; Saturn reaches perihelion during this span (e.g., 1996 to 2009…perihelion of 9.0AU in July 2003).
- In the 15.75^{y} period, Saturn's N pole and N ring face are tilted toward Earth; Saturn reaches aphelion during this time (e.g., 2009 thru 2025…aphelion of 10.1AU in April 2018).
- The last edgewise presentation of the rings occurred in 1995-96, which was extremely favorable and well-observed by the ALPO Saturn Section.
- This year, as the Earth crosses the ring plane on September 4th, Saturn is only 11º E of the Sun with conjunction only two weeks away, making observations very unfavorable.
- The next edgewise orientation of the rings occurs on March 23, 2025 with Saturn just 10º W of the Sun with the planet lost in the overwhelming solar glare.
- Unfortunately, the next favorable edgewise apparition won't occur until 2038-39!

The 2009 Edgewise Apparition: Graphic Overview

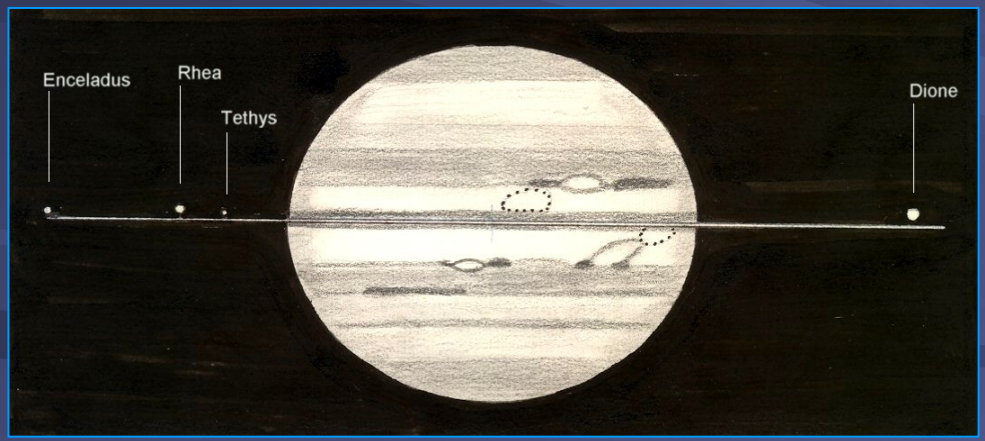


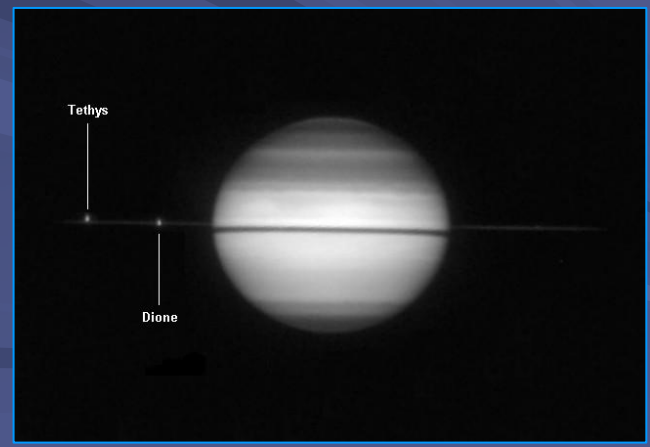
Observations During Edgewise Ring Apparitions

- It is interesting to see just how close to the theoretical edge-on date the rings can be seen or imaged with a given telescope, and there is a general asymmetry with respect to the extent, appearance, and brightness of the rings of Saturn at edgewise orientations.



- Saturn ring plane crossings are worthy of scientific study because when the rings are nearly edge-on to Earth, the glare from the rings is reduced considerably, and faint objects near Saturn, such as moons, are easier to see.

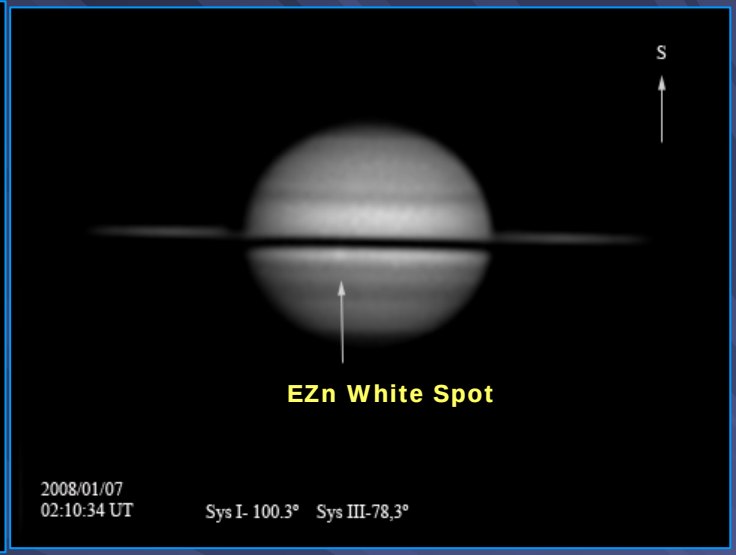




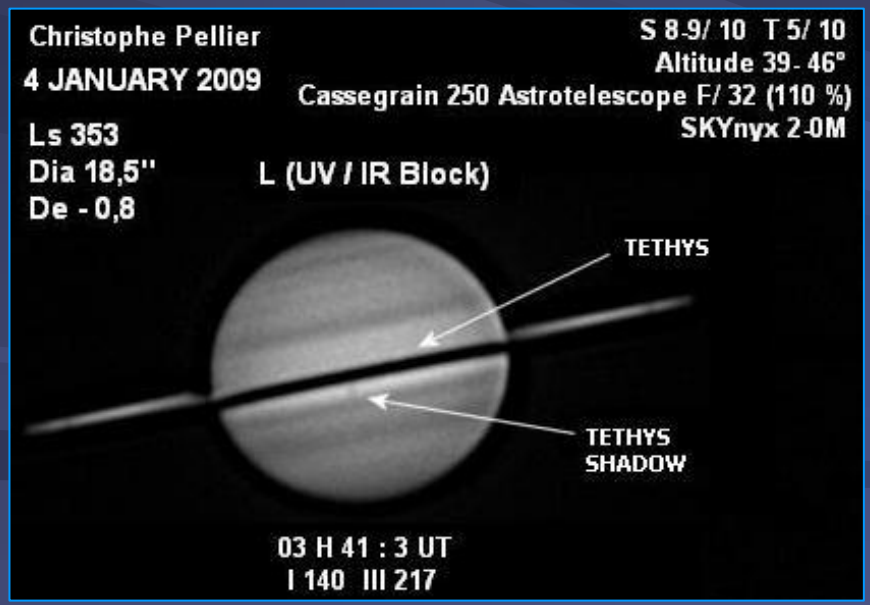
Observations During Edgewise Ring Apparitions

- Months before and after the ring plane crossings, unique observations of Saturn, its rings and moons can be made from Earth that are available at no other time, some within the realm of amateur work, such as:
  - ✓ This is the best time to discover a new moon around Saturn (13 of Saturn's moons have been discovered around the time of a ring plane crossing).
  - ✓ A large number of eclipses, transits, and occultations of the satellites by Saturn occur at small ring inclinations, and accurate timings of these events are used to improve ephemerides of the satellites.
    - ❖ *NOTE: Predictions for Saturn's satellites Mimas, Enceladus, Tethys, Dione, Rhea, Titan, and Iapetus are available on the Saturn page on the ALPO website.*
  - ✓ The cloud-tops of Saturn are more easily observed without the glare from the rings, to include photoelectric photometry of the globe.
  - ✓ The morphology and visual numerical relative intensity of belts and zones in the N and S hemispheres of the globe can be compared more readily with one another.
  - ✓ Direct observations of the thickness of the main rings can be performed.
  - ✓ The tenuous E and G rings may be observed or imaged from Earth, which are normally obscured from the glare from Saturn's rings.
  - ✓ The small inner moons of Saturn (Prometheus, Pandora, Janus and Epimetheus) can be observed with greater precision by the largest professional telescopes.
  - ✓ Observations of the dark side of the rings and of Ring C are possible during a ring plane crossing event.

Recent Observations of Saturn in 2009



Shadow of the Globe on the Rings is toward the East (IAU) prior to Opposition



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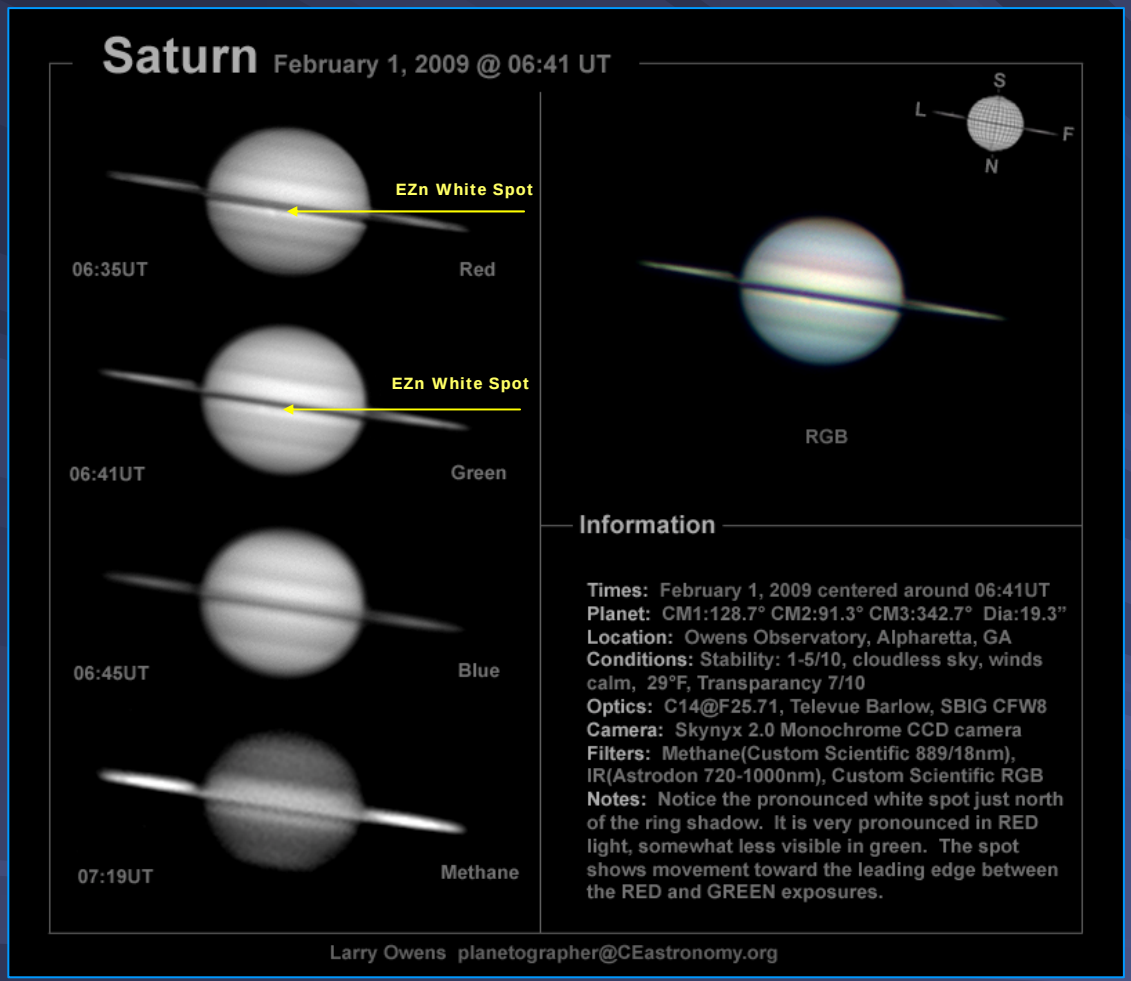
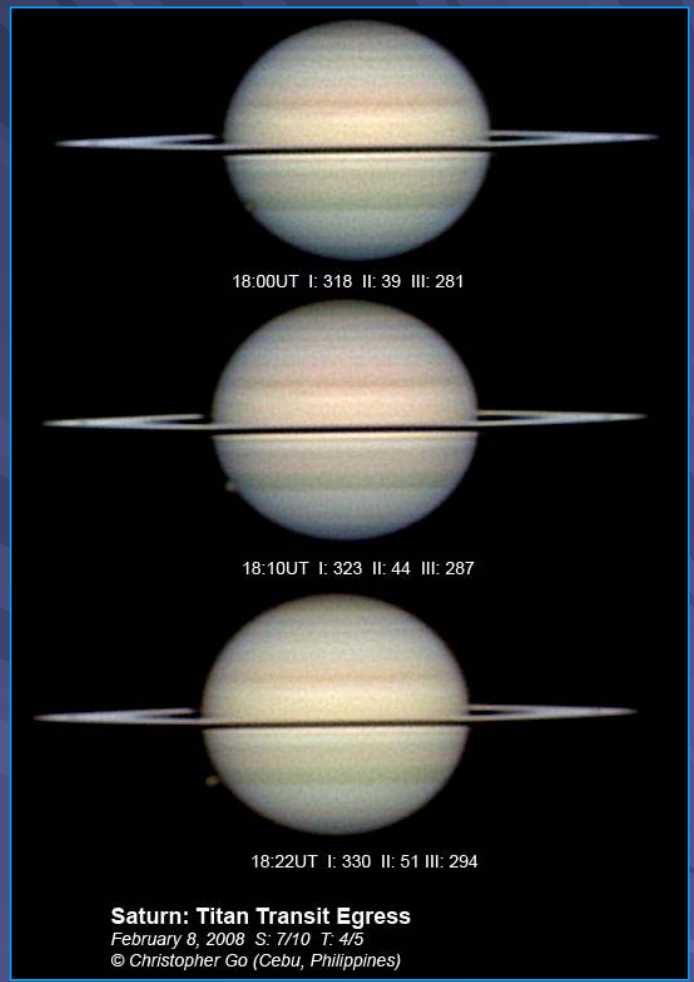
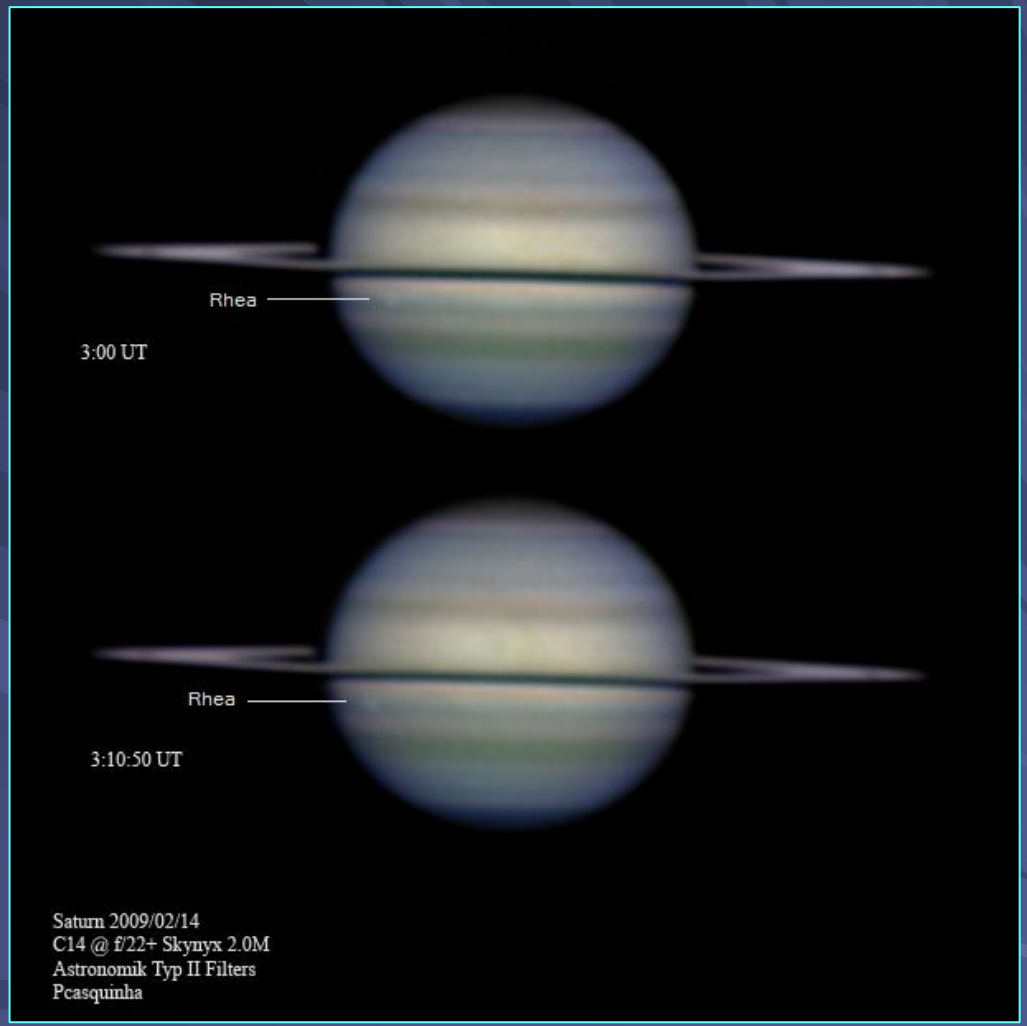
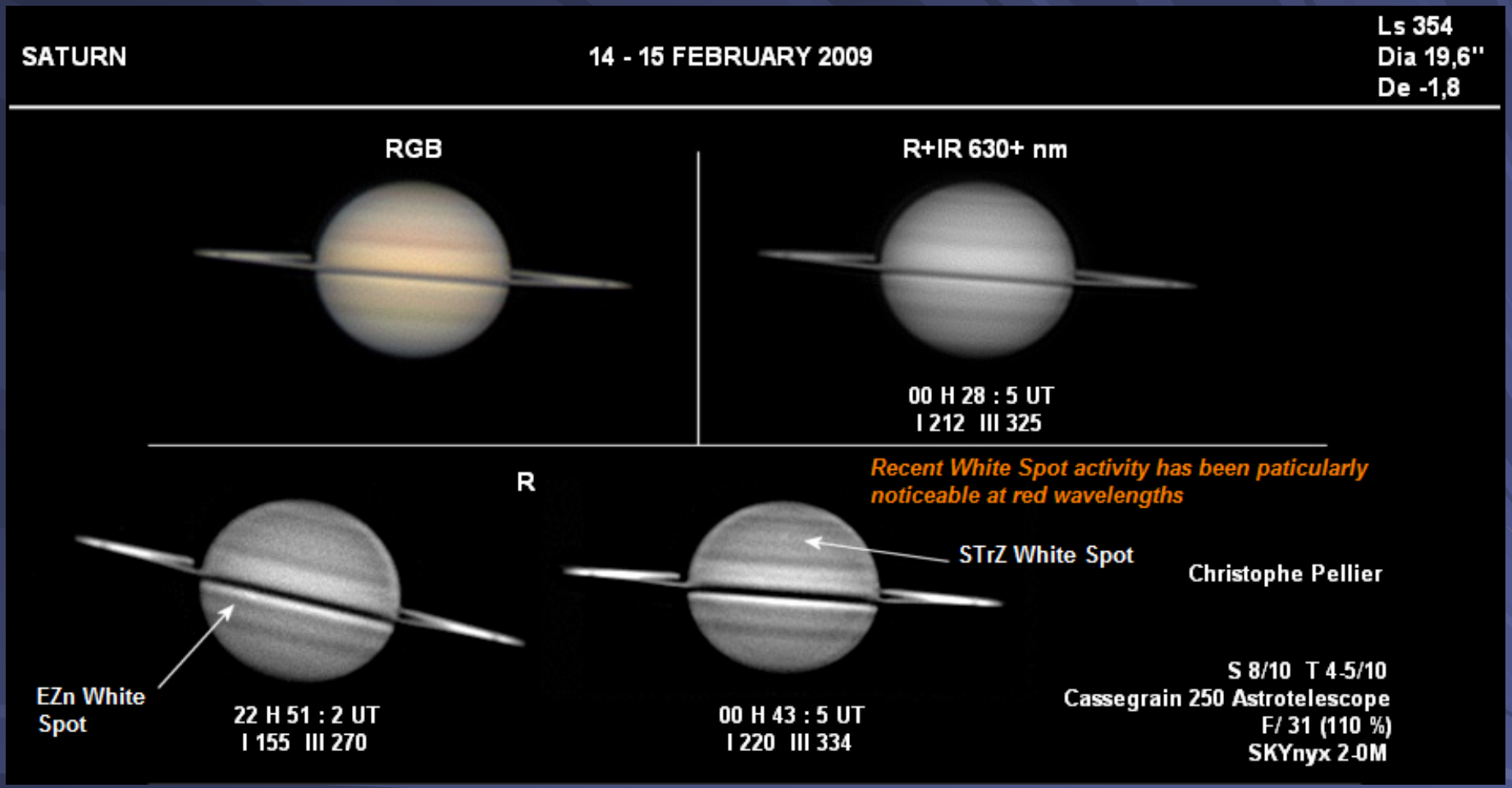




Recent Observations of Saturn in 2009



Recent Observations of Saturn in 2009



Closing Notes

- While 2009 is not favorable for seeing the rings precisely edge-on, their small inclination toward Earth provides a rare chance to view nearly equal portions of the S and N hemispheres of the globe.

  - ✓ Comparative analysis of similar belt and zones in the S and N hemispheres is possible with regard to their overall morphology, intensity, and width.
  - ✓ Observers are already reporting differences in the appearance of the N hemisphere vs. the S hemisphere of Saturn.
  - ✓ Activity such as white spots in the STrZ, SEBZ, and EZn have already been imaged, and it will be interesting to watch their development with time, as well as be on the lookout for new features that may emerge.

- The small ring tilt allows viewing and imaging of transits, shadow transits, occultations, and eclipses of satellites near Saturn's equatorial plane.

  - ✓ Excellent images showing transits of Titan, Tethys, and Rhea have been received, with more likely to come as the apparition progresses.
  - ✓ It will be interesting to see what imaging with various instruments reveals, since there is controversy as to whether shadow transits of satellites other than Titan are visible from Earth with large instruments (nearly all of the satellites are presumed to be too small to cast umbral shadows onto the planet’s globe).

A Special Event on February 24th (for some anyway)

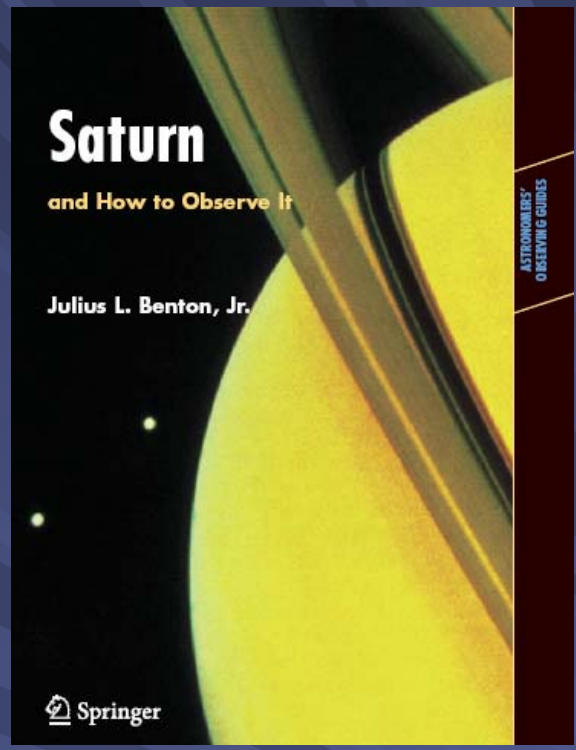
- Titan, Mimas, Enceladus and Dione will all cross the globe of Saturn on February 24, 2009 in an extremely rare *quadruple transit event*.

  - ✓ The transits begin at 10:54UT with Titan, followed by Mimas, Dione, and Enceladus.
  - ✓ By 14:24UT all four satellites and their shadows will appear together on the globe of Saturn.
  - ✓ The quadruple transit will be visible from the Pacific coast of North America, Alaska, Hawaii, Australia, and East Asia.
  - ✓ Amateurs in those regions may view and image the events at various wavelengths including methane (889nm) and UV (320-290nm).
  - ✓ Apertures in excess of 25.4cm (10in) will improve visibility of the smaller satellites and shadows.
  - ✓ In addition to Earth-based telescopes, the HST will be imaging these events; comparative analysis of observations from all sources should prove interesting.

- A special treat on the same date will be 6th magnitude Comet Lulin (C/2007 N3) less than 3° from Saturn.

More Information About Observing Saturn

An observing guide for Saturn, based on ALPO programs and methodology, formerly the ALPO Saturn Handbook, was published by Springer in late 2005 as part of the emerging Astronomers' Observing Guides series.



More information is also available, including up-to-date ephemerides, observing forms, latest observations, and more on the ALPO website at

http://www.alpo-astronomy.org/

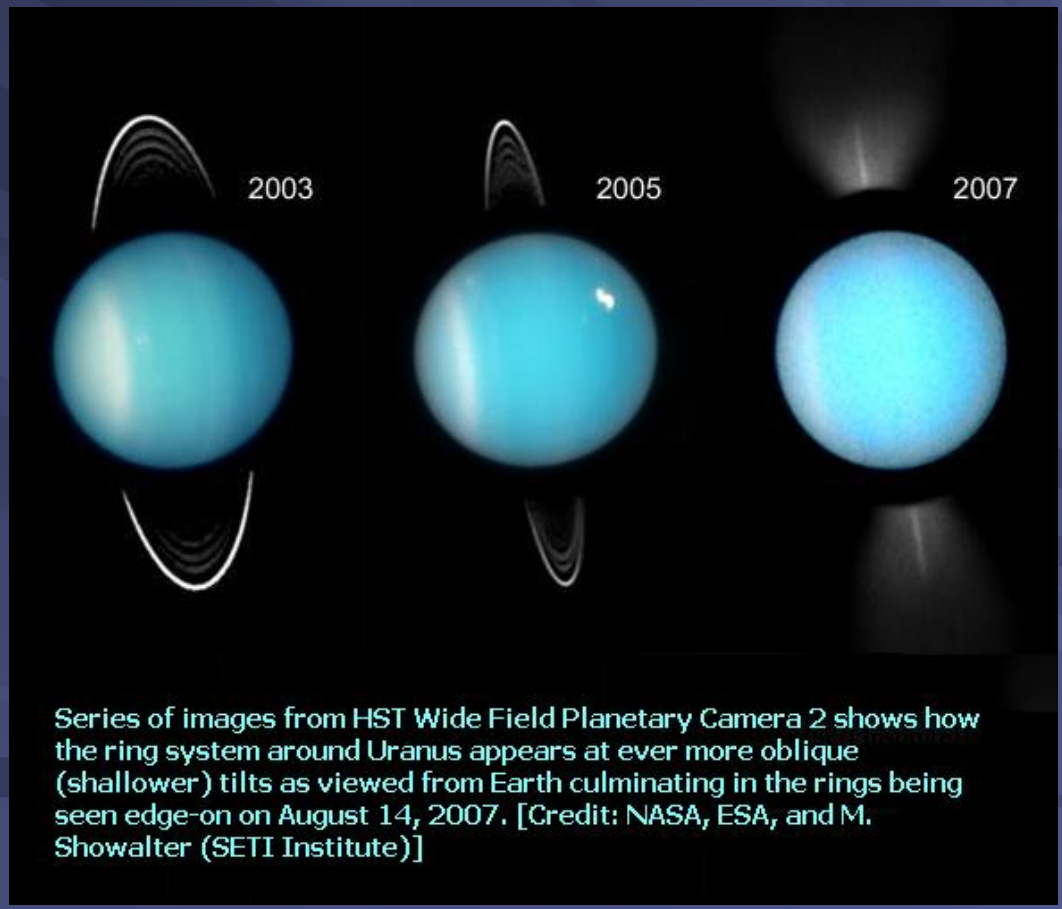
or on the Saturn Yahoo Group at

http://tech.groups.yahoo.com/group/Saturn-ALPO

Happy Viewing and Imaging!

Other Planets with Recent Edgewise Ring Orientations

- In case anyone is wondering if Saturn is the only planet with rings that can be viewed edge-on from Earth, the rings of Uranus are oriented edge-on to Earth every 42 years.
- In 2007 an unprecedented, glare-free view of the rings and the fine dust that permeates them occurred, and most of Earth's premier telescopes, including Keck, Hubble, VLT and Palomar, were turned toward Uranus



Series of images from HST Wide Field Planetary Camera 2 shows how the ring system around Uranus appears at ever more oblique (shallower) tilts as viewed from Earth culminating in the rings being seen edge-on on August 14, 2007. [Credit: NASA, ESA, and M. Showalter (SETI Institute)]