

# THE LUNAR PERIGEE-SYZYGY CYCLE FOR 1998: IMPLICATIONS FOR ASTRONOMIC TIDAL HEIGHTS

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## INTRODUCTION

**Syzygy** is the astronomic term for the lunar phases that appear when the centers of the Sun, the Earth, and the Moon lie along a common line. When the Moon is between the Sun and the Earth, the result is New Moon syzygy. When the Earth appears between the Moon and the Sun, the result is Full Moon syzygy. A common misconception in some textbooks is that because the gravitational pulls of the Moon and the Sun are combined during a New Moon syzygy as contrasted with the Moon pulling against the Sun at Full Moon syzygy, that the astronomic tides at New Moon always exceed those of Full Moon. This is not always correct. At some times, the tidal amplitudes at a New Moon syzygy phase are indeed greater than those at an immediately preceding or immediately following Full Moon syzygy phase. At other times, the tidal amplitudes of successive syzygy phases are identical. At still other times, the amplitude of the Full Moon syzygy phase exceeds that at the immediately preceding or immediately following New Moon syzygy phase. The explanation of this relationship is found in the interaction between the lunar phases and the progression in the plane of the Moon's orbit of the long axis of the Moon's elliptical orbit (a line astronomers have named the lunar **apse**). The time (8.849 yr) required for the lunar apse to rotate 360° defines the **apse cycle**. The motion of the lunar apse through the various lunar phases establishes the perigee-syzygy cycle, which is the coincidence of a syzygy phase with a perigee position. (**Perigee** is defined as an Earth-orbiting-body's closest approach to the Earth.) The time required for this coincidence to change from one syzygy phase to the other syzygy phase and back again is about 14 months, the duration of the **lunar perigee-syzygy cycle**.

The possible connection between lunar perigee-syzygy coincidences and devastating coastal storms has been emphasized by Fergus J. Wood (1978, 1985) in two important publications that have not been given the attention I think they deserve. Inspired by Wood's analysis, I have assembled the NOAA yearly tide predictions for Sandy Hook, NJ for the interval 1968-1998 and using QUATTRO PRO spreadsheets, I have prepared computer-drawn graphs for each month, to which I have added graphic indications of lunar phase, apogee and perigee, and lunar declination, a combination that I refer to as a Pettersson diagram, named after the Swedish oceanographer Otto Pettersson [1848-1941], who first devised them in 1909 as part of his study of the relationship between herring catches and internal tides in the Gullmarfjord, west coast of Sweden. Figure 1 shows an example for the predicted heights at Fire Island Inlet, NY for 1998. In addition, I have made graphs of the data tables in F. J. Wood's 1978 monograph and compared this curve with the monthly flow of the upper Hudson River at Green Island, NY (Figure 2).

In this paper, I review some of the lunar cycles that affect the amplitudes of the astronomic tides, give the details of the 1998 perigee-syzygy situation, present the lunar setting of the great coastal storm of 05-08 March 1962, and close with a few speculations about the possible importance of lunar cycles.

### **LUNAR CYCLES AND AMPLITUDES OF ASTRONOMIC TIDES**

Even those partisans who subscribe resolutely to the stochastic outlook with respect to the Earth's environmental variables will concede, even if they do so grudgingly, that natural cycles, such as day vs. night, the seasons, and the astronomic (lunar-solar) tides, for example, do exist and that these cycles demonstrably influence certain processes on the Earth. A clear and undoubted connection has been established between the cyclic variations of sea level and the variation in the gravitational tide-generating forces. The periods of the various lunar-solar cycles have been determined. Table 1 summarizes a few of the short-term lunar cycles.

These periods and others are the bases for the harmonic analyses used to compile the annual predictions of times and heights of high- and low water in coastal localities (Schureman, 1958).

### 1998 LUNAR PERIGEE-SYZYGY CYCLE

During 1998, two sets of triple lunar perigee-syzygy coincidences will take place, the first in the spring (perigee with New Moon on the Equator late in February, March, and April) and the second in the fall (perigee with Full Moon on the Equator early in September, October, and November). The most exact of the first set of these triple coincidences will be on 28 March, when lunar perigee coincides with New Moon (and the Moon on the Equator). The most exact of the second set will be on 05 October, when lunar perigee coincides with Full Moon (again on the Equator). The times of the year's highest predicted astronomic tidal heights (111 cm at Democrat Point, Fire Island, NY) are scheduled for 5 occasions: the evening tides of 26 and 27 April and of 25 May (New-Moon perigee-syzygy cycle peaks) and the morning tides of 04 and 05 November (Full-Moon perigee-syzygy cycle peaks).

Figure not available.

**Figure 1.** Monthly Pettersson diagrams for predicted astronomic tides at Fire Island Inlet, NY, for 1998. A and P in top row of letters/symbols indicate Apogee and Perigee, respectively. Middle row shows lunar phases (open circle, Full Moon; blackened-in circle, New Moon, half-filled circles, quarter phases. Letters in bottom row indicate lunar declination; N, Moon in far-north position; E, Moon over Earth=s Equator; S, Moon in far-south position.

Figure not available.

**Figure 2.** Lunar perigee-syzygy cycle and general similarities with rainfall. (After J. E. Sanders, 1995.)

Upper graph displays mean monthly discharge of upper Hudson River at Green Island, NY. (Data from U. S. Geological Survey.) Lower graph presents the lunar perigee-syzygy cycle in terms of variations in Moon=s mean daily motion. (Data from F. J. Wood, 1978, Table 16.)

**Table 1.** Some short-period lunar-solar cycles. (Compiled in part from Otto Pettersson, 1912, 1914b, 1930.)

Cycle Period

Daily: Earth's rotation 23 hours, 50 minutes.

**Lunar tidal cycle** If twice daily, 11 hr, 50 min

Monthly: Moon's orbit (**cycle of 29.531 days** (synodic period)).

**lunar phases)**

Seasonal: **Phase-declination cycle** Quarterly (syzygy and max lunar declination in June, month of summer solstice, hence max. N declination of the Sun in N Hemisphere; syzygy and Moon above the Earth's Equator in March and September, the months of the solar equinox; and syzygy and max. lunar declination in December, month of winter solstice, hence max. S declination of the Sun in N Hemisphere).

**Perigee/syzygy cycle** (the time 14 months required for lunar perigee at one syzygy phase to return to this same phase again after coinciding with the other syzygy phase).

**Lunar node-apse cycle** (the time 2.998 yr required for the apse and node, explained below, which move in opposite senses, to coincide).

**Syzygy-maximum-declination cycle** 8 yr (the time required for the same syzygy phase to coincide with the same maximum N or S declination in June or December)

**Lunar apse cycle** [the time required 8.849 yr for the long axis of the Moon's orbital ellipse (= **lunar apse**) to progress, in the plane of the Moon's orbit, by 360°]

**Lunar nodal cycle** [the time required 18.6134 years for the line formed by intersection of the Moon's orbital plane and the plane of the Earth's orbit (= **lunar node**), to rotate through 360°]

## **LUNAR SETTING OF THE GREAT COASTAL STORM**

## **OF 05-08 MARCH 1962**

One of the most devastating east-coast coastal storms on record took place during 05-08 March 1962 (Stewart, 1962; Cooperman and Rosendal, 1963; O'Brien and Johnson, 1963; Bretschneider, 1964). The U. S. Army Corps of Engineers referred to this storm as "Operation 5 High." New Moon, Perigee, and the Moon above the Equator all coincided on 06 March 1962. Thus the perigee-syzygy maximum in March coincided with the annual cycle of syzygy phase with lunar equatorial declination. When the Moon is over the Earth's Equator (as in the months of Spring and Fall Equinoxes), the diurnal inequality disappears. Thus, the amplitudes of morning- and night-time tides are the same. In March 1962, the 5 successive high tides fell into the category of super-elevated perigee-syzygy spring tides of nearly equal magnitudes. The storm center became blocked so that the high winds kept blowing all the while that the higher-than-normal astronomic tides of equal magnitude were moving in and out.

### **SPECULATIONS ON POSSIBLE EFFECTS OF LUNAR PERIGEE-SYZYGY CYCLES**

Whether the lunar perigee-syzygy cycles exert any other effects on the Earth apart from those related to the amplitudes of the astronomic tides on the surface of the ocean remains to be determined. A possible water-level effect that may appear in coastal sands is cyclic accretionary strata deposited when fair-weather berms build upward and in times of rapid spit growth (Massa, 1988 ms.; Massa and Sanders, 1989a, b). Otto Pettersson (1914a, 1914b, 1915, 1930) demonstrated that perigee-syzygy variations in the internal tides along the fresh-water/saltwater pycnocline, whose amplitudes amounted to about 50 m in the Gullmarfjord, western Sweden (ca. 100 times the amplitude of the water-level tide), governed the arrival times from the North Sea of schools of herring, which entered the Gullmarfjord along with larger-than-normal, perigee-syzygy AMoon waves. @ Comparable behavior could affect times of ventilation of otherwise-anoxic coastal basins.

Lunar-nodal cycle probably affects many environmental factors. Kaye and Stuckey (1973) emphasized the importance of this cycle. Using signal-processing

techniques, Currie (1987, 1994; also other examples cited in Friedman, Sanders, and Kopaska-Merkel, 1992) and Currie, Wyatt, and O'Brien (1993) have found evidence for an 18.6-yr signal in various atmospheric properties (pressure, rainfall, and dust-veil index), and weather-related human activities.

Cyclic variation in lunar-tidal global effects on the Earth's atmosphere may also be expected. I think a key question needing investigation is whether the Moon causes any changes in the distance that the Intertropical Convergence Zone (ITCZ) travels away from the Earth's Equator during its annual seasonal migration. Ferrell (1863) suggested that the seasonal northward migration of the ITCZ into the drainage basin of the Blue Nile is the main factor responsible for the seasonal flooding of the Nile River. If the Moon affects the distance the ITCZ migrates, then one would expect to see lunar periods in the quantity of water discharged by the Nile. Currie (1995) has presented evidence that Nile floods display lunar signals. Similarly, any variable-distance migration of the ITCZ would be expected to affect the strength of El Niños. Fairbridge (personal communication) reports finding lunar periods in the historical records of El Niños.

Pettersson (1914a) argued that long-term variations in lunar-tidal effects (as mentioned by Cartwright, 1974, for example) influenced the large-scale hydrographic situation in the North Atlantic and that these hydrographic changes affected the climate in the surrounding land areas.

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