

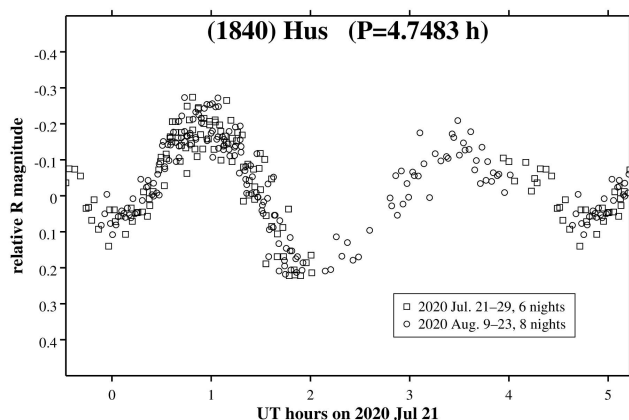


Figure 2. Folded composite lightcurve of (1840) Hus during its 2020 apparition, showing one rotation period plus the earliest and latest 10% repeated. The data are relative photometry only, and have been shifted in brightness to form a self-consistent composite.

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VISUAL OBSERVATION OF 3000+ MINOR PLANETS

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The author describes the results of visually observing 3,028 distinct minor planets over a 54-year period.

Unlike most celestial objects, the minor planets of our Solar System are both faint and constantly on the move, so that finding them is a challenge to the skill of visual observers. Tracking these small objects requires planning and perseverance.

The methods used to plan, prepare, observe, confirm, and record the author's observations of minor planets are described in Salthouse (2019). He started observing the major planets as a teenager in 1965, beginning with Jupiter and Saturn in a small refractor. His first minor planet observations began in late 1966 with a 4-inch reflector, and by the spring of 1967 he had captured 1 Ceres, 2 Pallas, 3 Juno, and 4 Vesta. These observations were enabled by charts in *Sky & Telescope* magazine (2020). Over the ensuing decades the author observed these four objects about one hundred times each.

Note that the author started this process before the internet, personal computers, spreadsheets, or even calculators. He performed all his calculations on blue-lined paper with a slide rule. Today, when he shows the latter to his colleagues, they have no idea how it works, but it is one of his favorite reminders of those days.

The process of tracking down minor planets was very haphazard for the next couple of decades, as the author was hampered by two key factors: a lack of information about where to locate many asteroids, and a lack of sufficient aperture to observe most of them.

Fortunately, the *RASC Observer's Handbook* (2020) and *Sky & Telescope* (2020) provided just enough information to track down a handful of bright asteroids over the years. Consequently, by 1990 the author had observed 35 distinct minor planets, a rather unimpressive result after 24 years of effort.

As with many amateurs, the author caught "aperture fever" and continually upgraded the size of his telescopes. He used a 10-inch equatorial reflector throughout the 1970s and 1980s but eventually purchased a 17-inch Dobsonian reflector in 1989. This was donated to a local community college and replaced by an 18-inch Dobsonian in 2007. Thus, all searching and tracking operations were fully manual.

Commencing in August 1990, the author had a private observatory to house his new reflector. Up to that point he had made only 190 observations of 35 different objects, but he used his new facilities to systematically re-observe every asteroid that he had seen before. More than 99% of all minor planet observations were made from this home observatory in central New Jersey.

Also, in 1990, the author was directed to Brian Warner, who was publishing the *Minor Planet Observer* print edition, which replaced by a web-only version in 2000 (Warner, 2020). This finally gave the author the means to begin a thorough and systematic search for every minor planet within the magnitude limit of his telescopes.

The combination of a new observatory with a large reflector and the *Minor Planet Observer* monthly publication and then web site was the impetus the author needed to initiate a serious search for minor planets. Over the 30-year period from 1990 August through 2020 August, the author visually observed more than 3,000 distinct objects.

The author quickly realized that visual identification of faint targets had its pitfalls, as each object had to be unambiguously identified from drawings of the star field made at the eyepiece. He then developed the “three observations rule”, which requires each object to be seen on at least two different nights *and* at least twice on the same night, confirming the motion against the stellar background. Objects that did not meet these criteria had to be rejected as unconfirmed.

This rule was always employed when searching for a minor planet for the first time, but it was relaxed somewhat when observing brighter objects at 2nd and subsequent oppositions.

Results

Between 1966 December and 2020 December, the author visually observed 3,028 distinct minor planets. All of the objects observed prior to 1990 August were subsequently re-observed.

Table I shows the entire set of observations arranged by the number of oppositions; 30% were observed at a single opposition, 38% were seen at two different oppositions, and the rest were seen at three or more. The dwarf planets Ceres and Pluto are excluded from the minor planet totals.

Oppositions	Observed
1	920
2	1,161
3–4	425
5–6	200
7–8	120
9–10	78
11+	124
Total	3,028

Table I. Number of minor planets observed vs number of oppositions.

Table II shows the distribution of observations arranged by minor planet number. The lowest numbered minor planet *not* seen was 452 Hamiltonia. Out of the first 1,000 numbered objects, sixteen were never seen.

Asteroid Number	Total Seen	Total Oppositions	Total Observations
2 – 1000	983	5,903	17,653
1001 – 2000	761	1,667	5,195
2001 – 3000	400	656	2,171
3001 – 4000	248	368	1,252
4001 – 5000	156	213	758
5001+	480	554	2,134
Minor Planets	3,028	9,361	29,163

Table II. Number of minor planets observed vs assigned number.

The median minor planet number observed was 1625. The author averaged 3.1 oppositions per minor planet, and 3.1 observations per opposition. Thus, the average number of observations per object was 9.6, but the median number was only 6. As one might expect, the distribution of observations per minor planet was highly skewed, with lower numbered objects being observed far more frequently than the higher numbered ones. Objects numbered 500 or less were observed 24.5 times on average whereas those numbered over 5000 were observed only 4.5 times each.

In addition to the minor planets, the author also made 450 observations of 64 comets, 294 of the dwarf planets Ceres and Pluto, 2,761 of the three rocky planets, and 7,663 of the four gas giant planets, for a total in excess of 40,000 logged Solar System observations.

There were roughly 4,300 known minor planets when the author began observing them in 1966. That number has grown more than a hundred-fold since, but the author at least has the satisfaction of having observed most of the objects known to exist at the time he started, plus several hundred more discovered after he began.

Acknowledgements

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