Notes on the Double Stars of Father John W. Stein, S. J.

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Abstract: Nearly half of the double stars listed in the WDS catalog have only the discovery measure. Opportunities abound for the dedicated amateur astronomer to confirm and measure these neglected pairs. This article highlights the photographic discoveries of Vatican astronomer, J W. Stein. About 18% of his pairs fit the neglecte category with the last measure averaging 90 years ago. A historical review is followed by an outline of the author's experience measuring Stein's pairs.

Brief History

In a monumental early effort to chart the entire sky to magnitude 11, the Paris Observatory developed the instrumentation and championed a program where about twenty nearly identical astrographs were built to plan and be installed by participating observatories each covering a specific declination zone. The Vatican Observatory was assigned the region +55 to +64 declination. This is generally known as the Vatican Zone of the *Astrographic Catalog*[1] *(AC)*. Over 256,000 stars were recorded for this zone alone. The Vatican photographic work began in 1895 and was completed in 1922. The deeper (14th mag) photographic charts from all zones , the *Carte du Ciel*, employed the same astrographs and contains over 12 million star images with the positions of 4.6 million measured, however, the high cost of reproduction prevented its completion and wide distribution.

Dutch born and educated, Dr. Stein (Figure 1) worked as assistant to the director of the Vatican Observatory, J. G. Hagen S.J., in the years 1906 to 1910. In 1910 he was appointed a teaching position at St. Ignatius College in Amsterdam where he taught mathematics, physics, botany and zoology During his teaching years he published many astronomical papers, most notable his section on the physics of variable stars in *Die Veränderlichen Sterne* . He always remained in close scientific collaboration with Hagen in these intervening years. Sometime after 1924 he

Figure 1: *Father John W. Stein, S.J. 1871 - 1951*

joined the Association of Dutch Amateur Astronomers where he contributed easily read synopses of professional astronomical literature for the association's journal and soon became its editor. In 1930 Stein was given the directorship of the Vatican observatory. The *AC* plate reduction process went on for years after the last plate was exposed in 1922 and Stein was there, off and on, through the thick of it, studying the early and recent plates to discover and measure his doubles, finally publishing his list: *Stelle doppie nel catalogo...Vaticano* (Rome, 1930). Stein was responsible for modernizing the observatory, including a new physics lab, and moving it to Castle Gandolfo just outside Rome in 1933 (see Figure 2 below). He was knighted to the Order of the Lion of the Netherlands by Queen Juliana and is also honored by the lunar crater Stein, located at 7.2 N , 179.0 E

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Figure 2: *The Vatican's* Carte du Ciel *astrograph used for zone 2 of the Astrographic Catalog. Photo courtesy Vatican Observatory web site.*

The Astrograph

Moved from the Vatican Observatory to Castle Gandolfo sometime after 1930 and dedicated in 1942, the astrograph's aperture is 13-inch (330 mm) and 135-inch (3,440 mm) focal length giving a focal ratio of 10.4. The 5-inch (130 mm) square blue sensitive glass plates covered 2 x 2 degrees of sky with a plate scale of 1 mm per minute of arc.

Color correcting the instrument for blue light (matching the blue sensitive plates) provided extraordinarily sharp images required for precise position work. An 8-inch (200 mm) aperture visually corrected, fine guiding refractor of about the same focal length as the camera is mounted co-aligned to the astrograph within the same rectangular tube, thus minimizing differential flexure. It also served as the field-centering instrument to ensure exact overlap of adjacent fields required in charting work. Operationally, two plates of each field were taken with the pointing slightly shifted for each. Generous field overlap of about 1 degree ensured complete coverage within the zone and adjacent zones.

The instrument is carried on a fine English equatorial yoke, which allows meridian passage without the usual mount flip of the more common German equatorial when working high declinations. Figure 3 shows a wonderful engraving by Poyet of the final design prototype at the Paris Observatory. Access to the pole was required for the Greenwich, England and Melbourne, Australia zones, thus a different mount arrangement was used.

Measuring Steins Doubles

Stein's (STI) discoveries, being photographic, tend to be rather faint for the visual (filar micrometer) observer, consequently about half of his pairs have only the discovery measure. Even many of those with six or eight measures can be called neglected with last measures sometimes 50 years old. The introduction of the CCD camera has changed the picture, making measurements of his doubles relatively easy. The magnitudes are mostly in the range of 9th - 14th in blue light. The accuracy of the listed B magnitudes are often quite a bit off, more than would be expected when quickly measured with a calibrated CCD in V and I-bands (B-V approximates V-I). Sometimes I find the secondary the brighter component in V-band, the accepted color for listing magnitudes. The possibility of a quadrant flip is slim with such wide and faint doubles.

Finding STI pairs visually requires a chart printout at the eyepiece and at least an 82 mm aperture finder for acquisition. I use Guide-8, a charting program from Project Pluto. The chart field is printed to

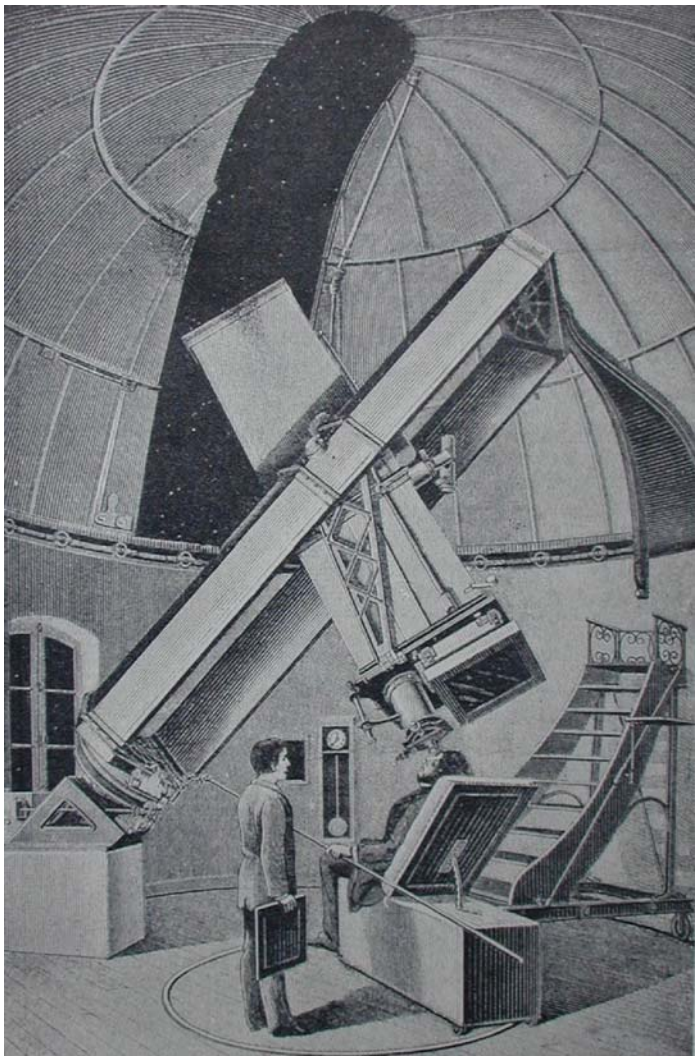

Figure 3: *Early engraving of the final prototype astrograph by the Henry brothers. From "Splendors of the Heavens", vol. 2 (1925).*

reflect the orientation and FOV of the finder. The separations of Stein's doubles are generally in the range of 3 to 15 arcseconds, very nice CCD objects. For LSO's 9-inch instrument, employing an ST-7 at 278-inch FL, the exposures tend to run in the range of 2 to 12 seconds unfiltered and 20 seconds and over for BVRI photometry. Pixel binning for photometric measures is preferred as long as the components are definitely separated. This keeps the exposure times reasonable. Delta m-wise, many of Steins doubles are of fairly equal magnitude, however, there are some really challenging examples where one wonders how he ever measured them photographically with the relatively short focal length of the instruments employed in the astrographic program. His precise measures stand as a testament of a careful and dedicated astronomer[2, 3].

Stein's Numbering System

Stein more or less divided his discoveries into two declination zones, essentially splitting the Vatican Astrographic zone. Doubles + 60 and higher in declination he numbered 1 through 1263 and those lower, 1364 through 3091, with both zones listed in order of right ascension. The series has many missing numbers. Due to precession since the discovery epoch, his number series no longer start close to 0 hours, beginning instead at about 0 hr 6 m (2000). Due to field overlap etc., his discoveries extend slightly outside the overall Vatican zone.

What to Expect

Photographic measures tend to be more accurate than filar work. In fact the CCD accuracy is generally comparable to photographic measures of wider pairs such as Stein's, therefore, a high confidence can be placed in detecting small relative motions. It is, of course, hard to say where the photographic and CCD measurement noise hides tiny motions. In my program to measure as many as possible of the neglected Stein doubles, I have noticed, thus far, that most show detectable relative motion where I define "detectable motion" as greater than 2-degrees in position angle and/or 0.2 seconds in separation. Naturally, for those pairs with only one previous measure, there is no way to tell if the motion is arcing concave to the primary, thus indicating physicality. Observing the colors and Δm photometrically and assuming main sequence objects can often help in this determination, however, almost nothing beats another observation, say fifty to one hundred years hence! Proper motion can also provide clues, however, these faint pairs often have no reliable data, especially for much fainter and close secondaries! Of course, if the primary is listed as having a clearly discernable proper motion and the pair's relative position has not changed much, we can assume they are traveling together through space, thus likely binary. From a "getting the job done"standpoint along with the usual time constraints, tedious analysis of most of Stein's pairs is not undertaken; just measure the position angle and separation and quickly move on to the next pair on the list! Unusual colors or delta m values are noted when encountered in hopes of returning to them another time.

Faint, well resolved double stars, other than dwarfs of spectral classes K- M, lie at tremendous distances where orbital times can be thousands of years. Studies[4] indicate that isolated main sequence doubles (especially spectral class F and G) in the range of 11th magnitude and separations of about 10 arcseconds and under have a high probability of being physical. This, shall we say, "rule of thumb" statistically includes many of Steins doubles. It is conceivable that up to 1/3 of Stein's pairs are physical! If true, it's a tremendous yield.

CCD Appearance of a Typical STI Pair

It is naturally desirable to measure such faint pairs in good seeing, but even when the images are a little blurry one can reach reasonable accuracy by av-

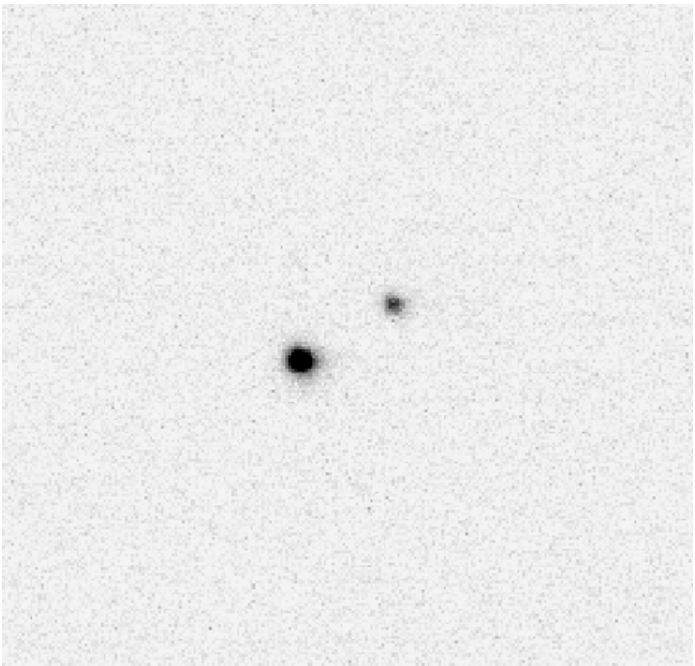

Figure 4: *Cropped CCD image of STI2222. The exposure was 3 seconds, unfiltered. Separation is 10.50". No other stars recorded in the full field!*

eraging measures from at least 12 selected CCD images. If I waited to measure only on the best nights very little work would ever get done! Amazingly, with my 9-inch refractor some semblance of an Airy disk is visible most nights and only about 5 clear nights a year (neglecting windy nights) are deemed useless. Strong north-west winds, especially at high altitude, is associated with degraded seeing at my location. A southerly flow that is very light at the surface gives the best seeing. Occasionally wind off the Atlantic penetrates inland enough (70 miles) to reach LSO and this can often provide fairly good seeing as well. The image of STI 2222 in Figure 4 was taken on 2006.301 during such a "sea breeze". The WDS mags are 9.7 and 12.5. North is up east is left.

Acknowledgement

Dr. Brian Mason of the USNO was extremely helpful to me in preparing this article. I especially thank Brian for finding a picture of Stein in Kort's memoriam to him (ref. 3) where many historical details were also gleaned.

References

1) Urban, Sean E.. and Thomas E. Corbin, "The Astrographic Catalog—A Century of Work Pays Off", *Sky & Telescope*, page 41, June 1998.

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3) J. de Kort S. J. In Memoriam, Father Johan Stein S. J. 1871-1951, Ricerche Astronomich, Vol 2, No.16, 1952.

4) Wolff D. Heinz, Double Stars, section 7: Optical and Temporary Double Stars, pg 17, 1978.