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THE CHRISTMAS STAR AS A SUPERNOVA IN AQUILA*

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ABSTRACT

Objections to a nova theory for the so-called "Christmas Star" are discussed and shown to be invalid. It is proposed that the Christmas Star was actually a sequence of three events: a series of planetary conjunctions and two novae. The present discussion, however, concentrates on the last of these, the nova of 4 B.C. It is suggested, moreover, that this event was not in fact a nova, but a supernova, and that the binary pulsar PSR 1913 + 16b is a result of that event.

The nature of the "star" that is supposed to have appeared when Jesus was born has been debated for ages. Explanations range from a miracle to nothing at all! One possibility is that it was a nova, or perhaps a supernova. Objections to the nova theory are often heard. One is that the Chinese recorded novae before the beginning of the Christian era, but they made no record of a new star at about the time of the birth of Jesus. Another, similar objection is that even if there had been a nova at that time, it could not have been bright, for if it had been the Chinese would not have missed it. This objection comes from the popular notion that the star was extremely bright.

Hence it is generally held today (see Hughes (1976), for example) that the "star" of the Magi was not a star at all, rather that it was a series of interesting planetary conjunctions which took place in 7 B.C. and 6 B.C. Indeed, if one visits almost any planetarium in the United States in December, he will probably be treated to a discussion of these interesting conjunctions. I propose here, however, that the "Christmas Star" was actually three unrelated events: the aforementioned planetary phenomena and two novae. The first of these was a series of conjunctions which,

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altogether, covered a period of eleven months and which began with the first of a triple conjunction of Jupiter and Saturn. The second was a possible nova which first appeared around March 24, 5 B.C., about eleven months after the end of the conjunctions. This nova appeared near the winter solstice point of that date, perhaps close enough to be of importance to the astrologically-minded Magi. The third event, which occurred almost eleven months to the day after the second one, was the appearance of another nova. This was first seen on February 23, 4 B.C., and was in the constellation of Aquila, near the intersection of the winter colure and the equator of date. Therefore its position may also have been of importance to the Magi, as perhaps were the recurring eleven-month intervals. This is just speculation, however; although when discussing astronomical events of millenia ago, one is often forced to build a case on speculation and circumstantial evidence. In this note, I will restrict myself to a discussion of the 4 B.C. event.

In the 3rd volume of *General Catalogue of Variable Stars* (Kukarkin *et al.* 1969–71, hereafter denoted as *GCVS*) there is a compilation of data on ancient and medieval supernovae and novae. The above-mentioned objection to a nova theory is refuted when we note in this table that a nova on February 23, 4 B.C. was recorded in China, Korea and Palestine. The *GCVS* gives the approximate position of the nova as R.A. = 20^h, Dec. = +10° (1900) and it states that the Chinese termed it a "scintillating star" rather than the more common "guest star". Of course, these terms are rather ambiguous at best. Sometimes the ancient Chinese used stellar terms for objects we think today to have been comets, and may have occasionally used cometary terms for stellar objects (see Ho (1962)). The term "scintillating star" may indicate that this object was brighter than the usual entry. Indeed the Chinese recorded "scintillating stars" at average intervals of 41.4 years between 108 B.C. and A.D. 390. As the brightest novae of our own century occur at intervals of 20 years or so on the average, it would seem that there is some evidence that the ancient Chinese "scintillating stars" were quite bright. Thus, although the Bible never said that the Christmas Star was bright, there is evidence of a rather bright nova in 4 B.C.

Ancient texts are rather inaccurate in giving positions. For instance, in the case of the 4 B.C. event, it is recorded that it appeared "at Ho-Ku", which was an asterism consisting of our α, β and γ Aquilae. Therefore, in the *GCVS* the position has been rounded off to an accuracy of ±10°. If the 4 B.C. event were not a nova, but a *supernova*, then a pulsar could have resulted from it. In a circular region of the sky, of radius 10° and centred either on the *GCVS* position or on "Ho-Ku", there are many pulsars. In fact, Kiang (1969) identified one of these, PSR 1929 + 10, with the 4 B.C. event (but with only a low probability). Since 1969, more pulsars have been discovered near α Aql and one of them certainly has some interesting characteristics as far as a possible relation to the 4 B.C. event is concerned. Hulse and Taylor (1975) discovered PSR 1913 + 16b, a binary pulsar, which is located about as far from "Ho-Ku" as is the approximate *GCVS* position. The *Third Supplement* to the *GCVS* (Kukarkin *et al.* 1976) gives the position of PSR 1913 + 16b as R.A. = $19^h13^m13^s$, Dec. = $+16°00'24''$ (1950), which means that it is $5°47'$ from γ Aql (using the position of γ Aql given by Bečvář (1964)).

From the above 1950 position of PSR 1913+16b, and using $23°27'$ and $50''.26$ yr^{-1} for the obliquity of the ecliptic and the constant of precession respectively (neglecting secular changes in these constants and other refinements), the position of this pulsar in 4 B.C. is found to have been R.A. = $17^h44^m35^s$, Dec. = $+14°38'.5$. If this pulsar originated in a supernova in 4 B.C., one might wonder whether this celestial position might have had any special significance to the Magi. Indeed, taking $+31°.775$ as the latitude of Jerusalem and 200° as the azimuth of Bethlehem as seen from the Old South Gate of Jerusalem (the gate that led to Bethlehem), then at local sunrise (zenith distance of centre of sun = 90°) on the first day of the year (March 21, 4 B.C.), the supernova would have been at the azimuth of Bethlehem, as seen from the Gate, at an altitude of 72°! This may have been of great significance to people who looked for celestial "signs" and the like. Perhaps it accounts for the passage in the Bible (King James Version, Matthew 2:9): "And, lo, the star, which they saw in the east, went before them, till it came and stood over where the young child was."

Hulse and Taylor (1975) estimate the distance to PSR 1913+16b as 5 kpc, with 5 to 10 magnitudes of optical extinction between the pulsar and earth. If this pulsar were the result of a supernova in 4 B.C., the apparent magnitude of the supernova at maximum would depend on whether it was of Type I or of Type II, as well as on the amount of optical extinction. Minkowski (1964) gives the following estimates of the absolute visual magnitudes of supernovae at maximum: for Type I, $M_V = -18.9$; for Type II, $M_V = -17.5$. (One can also consider the supernova S Andromedae in M31; it reached an apparent magnitude of +6 in 1885 (Kukarkin *et al.* 1969–71), corresponding to an absolute magnitude of -18.1, for a distance of 675 kpc and neglecting optical extinction.) Thus if SN Aql 4 B.C. attained any of these three absolute magnitudes its apparent magnitude would have been brighter than -4.0, neglecting extinction and assuming a distance of 5 kpc. Of course, the extinction must be considered and if it were as great as 10 magnitudes the star probably would not have been seen at all. For 5 magnitudes of extinction, however, the star's apparent magnitude would have been brighter than 1.0. Moreover, the extinction or distance could even be less.

Smarr and Blandford (1976) have estimated the age of PSR 1913+16b. Using different models they concluded that its age is ~1,000,000 years, or perhaps $\lesssim$200,000 years. No evidence has been found for an optical or radio supernova remnant, although one would expect one if PSR 1913+16b were as young as 2,000 years. However the more recent supernova of A.D. 1006 left only a weak radio remnant, so this argument against an age of ~2,000 years is not overwhelming. Also, because PSR 1913+16b is a *binary*, it is clearly different from other pulsars. What the differences are is not known, however. Still, it is interesting to compare its period with those of the Crab and Vela pulsars. The Crab pulsar, NP 0531, has a period of 0.033 s, and the Vela pulsar, PSR 0833-45, has a period of 0.089 s; these are the shortest and third shortest periods for the known pulsars (Kukarkin *et al.* 1976). In comparison, PSR 1913+16b has a period of 0.059 s, the second shortest period known. It is well known that the periods of most pulsars slowly lengthen, and it is quite certain that the Crab pulsar is 924 years old (in 1978) while the Vela pulsar is 6,000 to 11,000 years old. (Michanowsky (1976) has recently translated an ancient Sumerian tablet which shows a temporary and very bright star in what we would call Vela, the age of the tablet being 6,000 years according to him.) Thus, if these three pulsars were born with approximately the same periods and have evolved similarly, the Aquila object could be between 1,000 and 6,000 years old – perhaps 2,000 years!

References

Bečvář, A. 1964, *Atlas of the Heavens II, Catalogue 1950.0*, Sky Publishing Corp., Cambridge, Mass.

Ho Peng Yoke 1962, *Vistas Astron.*, **5**, 127.

Hughes, D. W. 1976, *Nature*, **264**, 513.

Hulse, R. A. and Taylor, J. H. 1975, *Astrophys. J. Letters*, **195**, L51.

Kiang, T. 1969, *Nature*, **223**, 599.

Kukarkin, B. V., Kholopov, P. N., (Pskovsky, Yu. P.,) Efremov, Yu. N., Kukarkina, N. P., Kurochkin, N. E., Medvedeva, G. I., Perova, N. B., Fedorovich, V. P., Frolov, M. S. 1969–71, *General Catalogue of Variable Stars* (Third Edition), Astron. Council of the Academy of Sciences of the U.S.S.R., Moscow.

Kukarkin, B. V., Kholopov, P. N., Fedorovich, V. P., Frolov, M. S., Kukarkina, N. P., Kurochkin, N. E., Medvedeva, G. I., Perova, N. B., Pskovsky, Yu.P. 1976, *Third Supplement to the Third Edition of the General Catalogue of Variable Stars*, Astron. Council of the Academy of Sciences of the U.S.S.R., Moscow.

Michanowsky, G. 1976, quoted in *Sci. Am.*, **235**, 66.

Minkowsky, R. 1964, *Ann. Rev. Astron. Astrophys.*, **2**, 247.

Smarr, L. L. and Blandford, R. 1976, *Astrophys. J.*, **207**, 574.