

# A Companion to the Eclipsing Variable AF Arietis

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**Abstract:** In this paper the eclipsing variable star AF Arietis is shown to have a wide 12<sup>th</sup> magnitude companion, currently not included in the WDS catalog. The identified component appears to be following the same space motion as the 6<sup>th</sup> magnitude AB eclipsing pair and is situated at a broadly similar spectral distance from Earth, which suggest it might be a physical member of the system.

## Introduction

AF Arietis is a little known variable star to be found 3.5° east of Hamal, the leading star in Aries (Figure 1). Positioned at ICRS 02<sup>h</sup> 22<sup>m</sup> 06.62<sup>s</sup>, +22° 52'

24.93"(2000.0), AF Arietis has a mean apparent visual magnitude of 6.61 and it also bears the catalog designations of HIP 11035 and HD 14595. The SIMBAD database describes AF Arietis as an eclipsing binary of Al-gol type (detached).

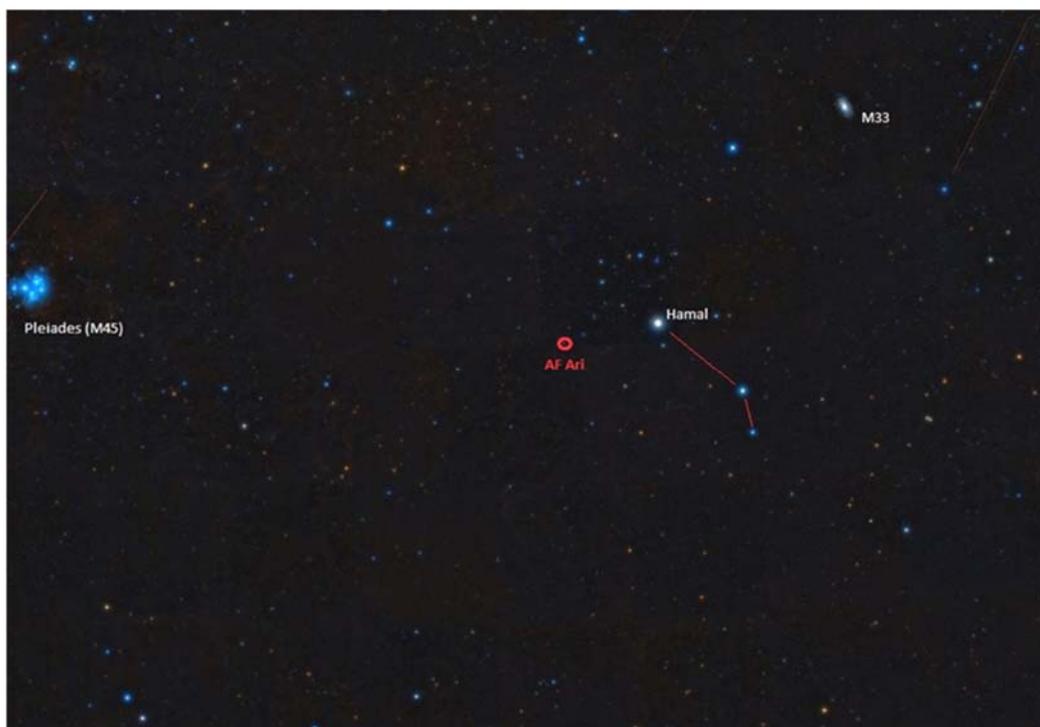


Figure 1. Location of AF Arietis [Source: SDSS]

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### Observations and Analysis

Hauck [2011] states that the AF Arietis system is a well-detached binary whose components revolve around each other in an eccentric orbit over a period of 153 days. Various orbital parameters are then provided, and the components are identified as a spectral type G3III giant which is being orbited by an A5V main sequence dwarf. The latter causes the eclipses that result in the observed variation of light from the system. Mass estimates are also provided for the A and B components of  $2.65 (\pm 0.15)$  and  $1.85 (\pm 0.05)$  solar masses, respectively.

The AAVSO database [2] was queried for the period 2002 December 7th to 2007 October 16<sup>th</sup>, which confirmed the light curve of AF Arietis and showed it to be fluctuating between V mag 6.3 to 7.1. The variability type is listed as an Algol-type eclipsing binary in both the GCVS and SIMBAD databases. From the frequency and depth of the observed eclipses and the detached nature of the components in this system it is very similar to the Zeta Aurigae system. A measured parallax of  $5.31 (\pm 0.53)$  milliarcseconds places the AF Arietis system at a distance of  $615 \pm 60$  light-years ( $190 \pm 20$  parsecs) from Earth. Hauck (2011) stated the AB components to have an orbital semi-major axis of 0.97 AU. At a distance of 615 ly, this translates to an angular separation of just  $0.005''$ . This means the eclipsing components of AF Arietis would only be resolvable into two separate stars with advanced imaging techniques and using instruments of large aperture. Consequently, for the purposes of “visual” double star observing, AF Arietis will appear as a single star in all amateur sized telescopes. In the remainder of this paper, the combined astrophysical characteristics of the eclipsing pair, such as their total visual brightness, proper motion, color index, etc shall therefore be collectively referred to as the “A component”. The new 12<sup>th</sup> magnitude outlying companion reported in this paper will henceforth be referred to as the “B component”.

I imaged AF Arietis for the very first time as a double star using the SSON 61-centimeter Cassegrain telescope [3] on 2014 September 4<sup>th</sup>. I later visually observed and sketched it with a Skywatcher Evostar 120mm refractor on 2014 September 24<sup>th</sup> at 21:20 UT (Figure 2).

Even though there is a large  $\Delta m$  of over five magnitudes between components in this double, the new companion can still be glimpsed in small aperture telescopes. Providing that a moderate amount of magnification is used to isolate it from the glare of the bright primary, the faint companion presents itself as a ghostly speck of light on clear moonless nights.

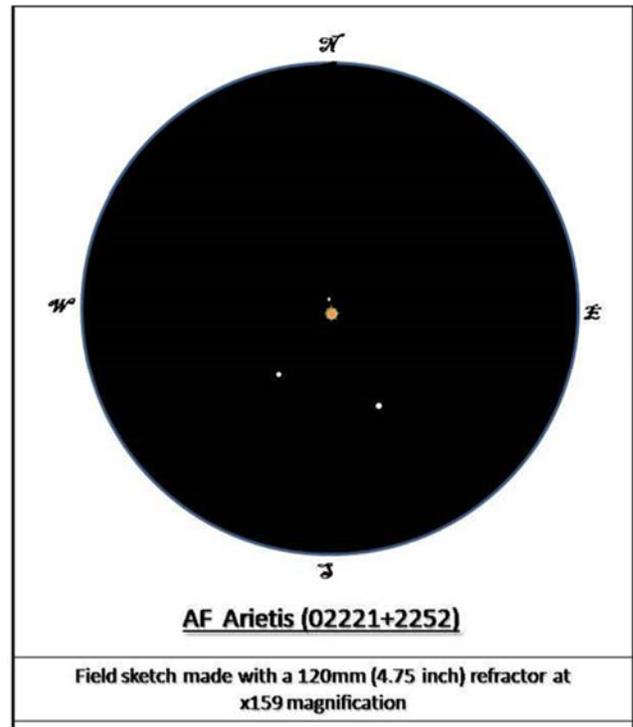


Figure 2. Field sketch made by the author showing the new B companion to the north of the 6<sup>th</sup> magnitude primary, which appeared a shade of pale bronze in color.

Astrometry performed on the SSON FITS image confirmed the latest measurements in 2014:

Position Angle ( $\theta$ ):  $347.4^\circ$  (epoch 2014.676)

Separation ( $\rho$ ):  $28.33''$  (epoch 2014.676)

The UCAC4 catalog [4] highlighted the components to be sharing common proper motions, as shown in Table 1.

Note that the proper motion vectors are closely aligned in both magnitude and in direction, considering the small error margins in each.

From the 2MASS catalog [5], I provide J and K-band magnitudes for the component stars shown in Table 2.

Given the eclipsing nature of the A component, where both its brightness and color are variable over time, the 2MASS (J-K) color index in Table 2 is not an absolute indicator of spectral classification in this particular instance. However, I believe G3III classification stated by Hauck (2011) to be a more accurate fit than the G2IV spectral classification currently in SIMBAD. A G3III giant star typically has an absolute magnitude around  $+0.5$ , which, when inserted into the distance

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Table 1: Proper Motion of the Components

	PM in RA	Error	PM in Dec	Error
A component	-13.6 mas/yr	±1.0	-1.3 mas/yr	±1.0
B component	-10.2 mas/yr	±1.3	-2.0 mas/yr	±0.9

Table 2: 2MASS Photometry

	J mag	K mag	Color Index (J-K)
A component	5.282	4.461	+0.82
B component	10.493	10.060	+0.43

modulus formulae along with the mean V mag of 6.61, further supports the parallax-measured distance of the primary in the region of 600 ly.

The B component identified in this paper is of approximate V mag ~12, which is consistent with it being a main sequence dwarf placed at the 600 ly estimated distance of the system. Its color index of +0.43 stated in Table 2 is probably slightly reddened by interstellar absorption, given that the distance of this system is twice that of similar systems studied in past papers which were typically between 200 to 400 ly away. Applying a small correction for interstellar reddening of -0.05 to the B component's color index, yields an improved fit to a late G / early K-type dwarf in the 2MASS (J-K) table [6]. Now late G-type dwarfs typically tend to be of absolute magnitudes of around +6. This value, when combined with the apparent V mag of 12 in the distance modulus formula, then gives a distance of the B component of just over 500 ly. This places the B component at a broadly similar distance from Earth as the A component's 600 ly shown above.

Assuming a similar distance of 600 ly, the angular separation of 28.33 arc seconds translates to a projected linear separation of about 5200 AU.

This distance - although vast - is still nevertheless within acceptable limits for the components to be loosely gravitationally bound, as was previously shown by using the  $\alpha$  Librae system as an example [7].

### Conclusions

Given the similar proper motion shared with the variable A component, and it being of a visual brightness and a 2MASS (J-K) color which are both consistent for it to be a main sequence dwarf placed at the same physical distance, on a balance of probabilities, the new B component is probably a physical member of the system rather than an optical one. It is recommended that AF Arietis be

added to the WDS catalog as an exciting new visual double star.

### Acknowledgments

This research has made use of the SIMBAD and VizieR databases maintained at the Centre de Données astronomiques, Strasbourg, France and the Washington Double Star catalog maintained at the US Naval Observatory. The AAVSO database was accessed to ascertain the variable nature of the primary. Appreciation is also expressed to Dr William Hartkopf at the USNO for reviewing the paper and for providing helpful comments.

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