SPA Annual Report – 2021.

Over the course of 2021, numerous members contributed observations to the Variable Star Section. These members were: Bob Steele, Dave McCraken, Don Matthews, Doug Allen, Jeff Stevens, Jonathan Shanklin, Tracie Heywood, Brendan Shaw, Ed Sawyer, Mary McIntyre, Keith Moseley, Paul Sunderland and Stanley Allen.

The major events of 2021, were nova Cassiopeia 2021 (V1405) and an outburst of RS Ophiuchi.

Nova Cassiopeia 2021 – V1405.

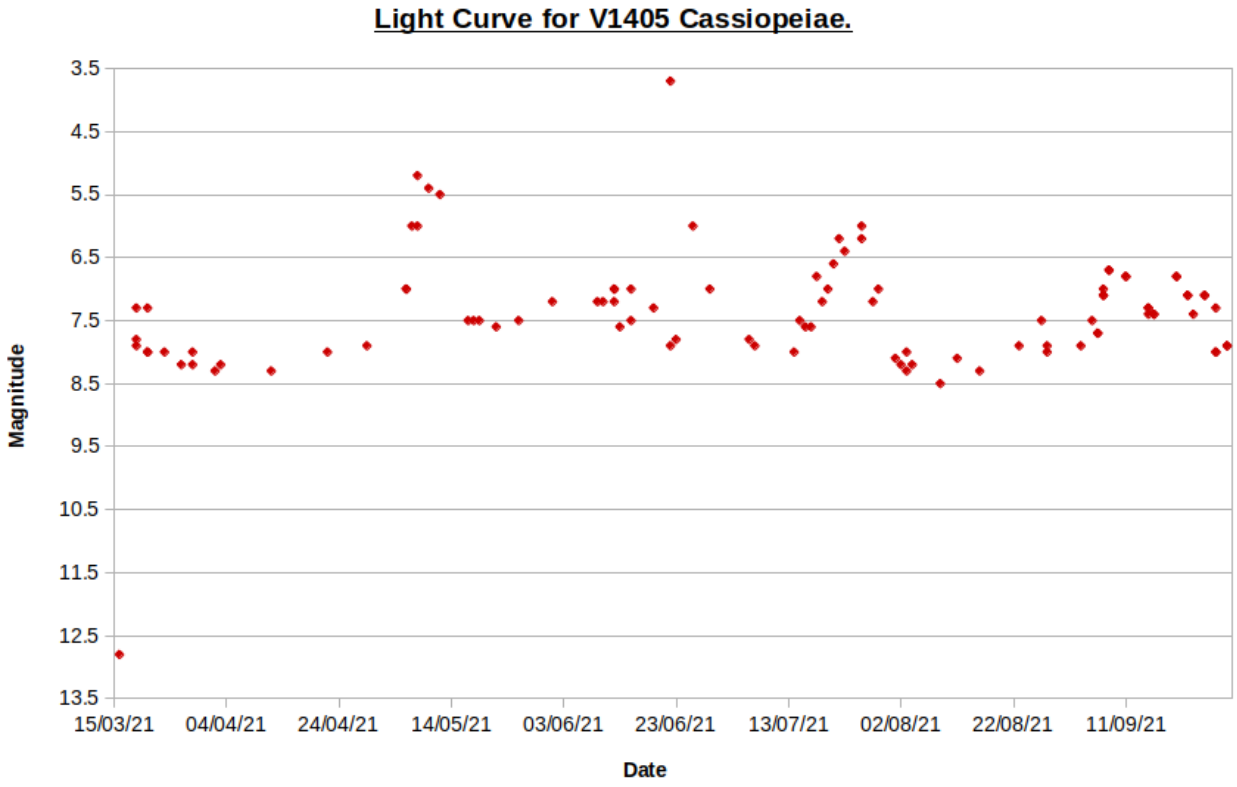
On the 18th of March 2021, a Japanese astronomer, Yuji Nakamura, from Kameyama in the Mie Prefecture of Central Japan, discovered a new star. He reported his discovery to the Okayama Observatory, who were able to conform his observations. A spectrum taken with the 3.8m Seimei telescope, confirmed that this new star was a classical nova. This nova was situated in the constellation of Cassiopeia, at coordinates 23h:24m:48s, +61°:11':14".

At the time of discovery, the nova had a magnitude of 9.6, but it rapidly rose to magnitude 7.8 over the course of 24 hours. By the 20th of March it had reached an initial peak of 7.5, eventually fading to magnitude 8.5 over the first few days of April. However, what makes this particular nova so interesting is that it then rose in brightness a second time, to magnitude 5.2, during the first few days of May. This makes nova V1405 Cassiopeia, as it has now been designated, the brightest nova seen from the UK since nova V339 Delphini in 2013.

Nova represent the rapid brightening of a once faint star as material is thrown off a white dwarf star. The white dwarf star will be orbiting in close proximity to its companion star – usually a red giant. The immense gravitational pull of the dense white dwarf, pulls material away from the companion star. This material builds-up upon the surface of the white dwarf. The pressure and temperature, upon the white dwarf's surface, increase until the temperature reaches about 10 million degrees, then a runaway thermonuclear reaction occurs and the accumulated material is ejected into space. Material was recorded leaving V1405 Cassiopeia at speeds of 1600 kms^{-1}.

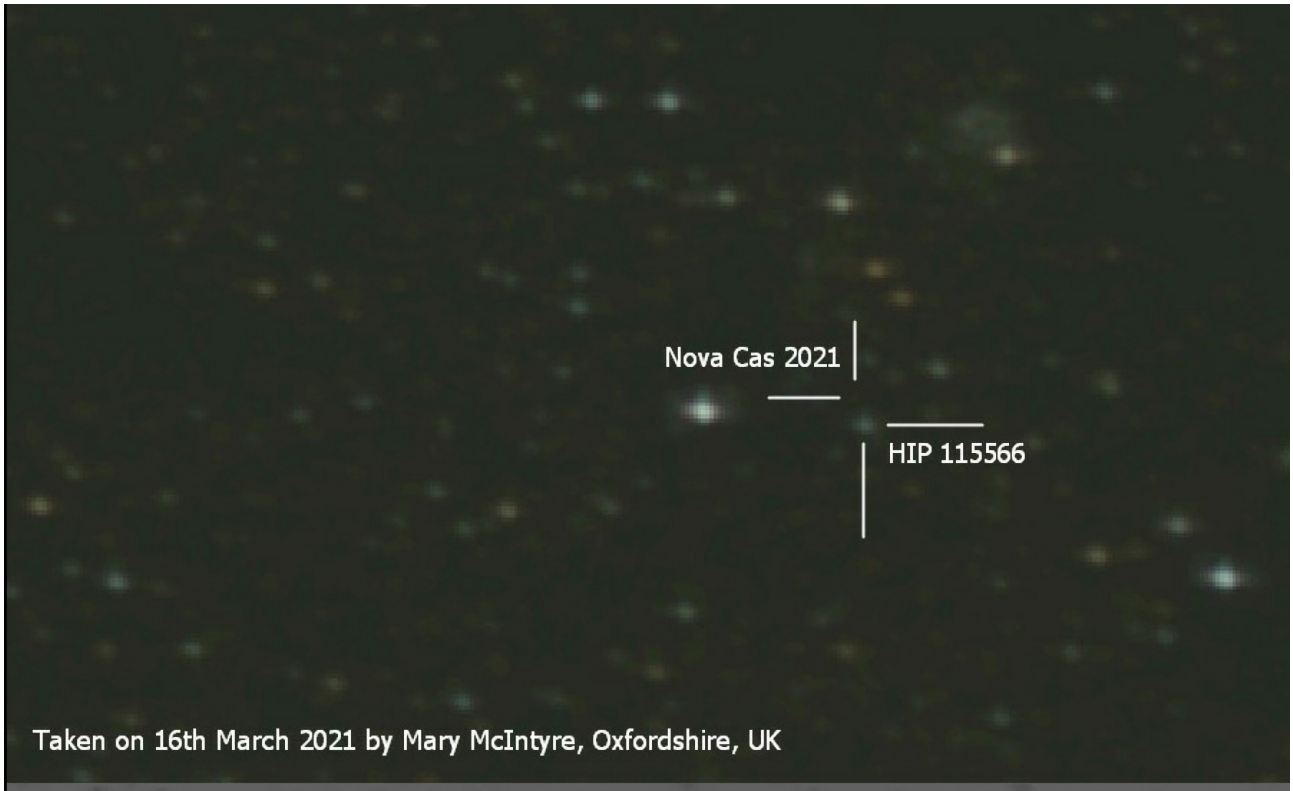
Nova V1405 Cassiopeia is an example of a slow novae. Slow novae are characterised by a gradual rise to brightness. They may spend weeks, or even months, at maximum brightness, before slowly declining in brightness. They very often display a sudden drop in brightness, before exhibiting a second rise in brightness. This second rise in brightness is caused by a second eject of material from the star's surface. During the initial outburst, only the outer layers of material are thrown off, so there is still plenty more material to be released.

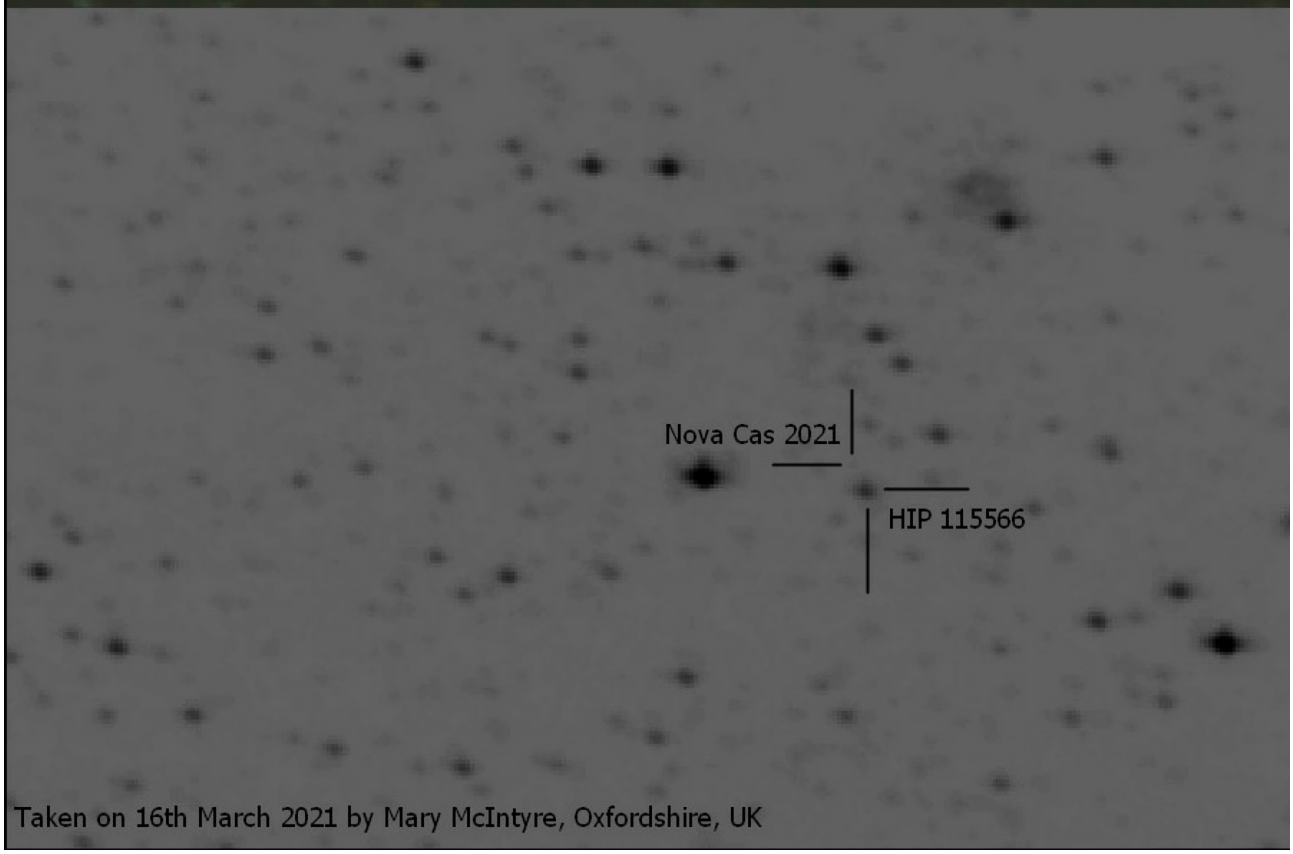
Observations of V1405 Cassiopeia were submitted by Mary McIntyre, Keith Moseley, Paul Sunderland, Stanley Allen, Bob Steele and Matthew Barrett. Mary McIntyre sent in some pre-discovery images of V1405 Cassiopeia, which showed the star at magnitude 12.78 on the 16th of March. Bob Steele was the first member to observe the second increase in brightness. He observed the star at magnitude 6.0 on the 8th of May.



V1405 Cassiopeia – Keith Moseley.

Pre-Discovery Images by Mary McIntyre.





RS Ophiuchi.

RS Ophiuchi is an example of a cataclysmic variable, which are stars that undergo rapid, and unpredictable changes in brightness. More specifically, RS Ophiuchi, is an example of a recurrent nova, which are a sub-category of cataclysmic variables. Recurrent nova are very rare objects – only seven such objects are known to astronomers.

Recurrent nova are represent by a physical system, similar to that of a classical nova. Once again we have a binary system consisting of a white dwarf and a red giant. Material is pulled, from the red giant, onto the white dwarf, until the unstable material is thrown from the surface of the white dwarf via a thermonuclear explosion. The difference between classical nova, and recurrent nova, is the frequency and amplitude of the outbursts. Classical nova occur once, and display a brightness increase of 8 – 15 magnitudes. By comparison, dwarf nova, another sub-category of cataclysmic variables, have more frequent outbursts, usually with a period of 10 -1000 days, and a small to moderate amplitude of 2 – 6 magnitudes. Recurrent nova, are placed between these two extremes, with less frequency outbursts then classical outburst, but larger magnitudes then dwarf nova. RS Ophiuchi has undergone five outbursts: once in 1898, then again in 1933, 1958, 1967 and 1985. RS Ophiuchi usually hovers around magnitude 12.5, but when in outburst, it can reach magnitude 4.8.

On the 8th of August 2021, RS Ophiuchi demonstrated a 600-fold increase in brightness in a single day. The outburst was first detected by Irish amateur Keith Geary, who imaged the star, at magnitude 5.0, at 22:20 UT using a DSLR. This outburst was confirmed 25 minutes later by Brazil amateur Alexandre Amurim; who observed it visually with a pair of binoculars.

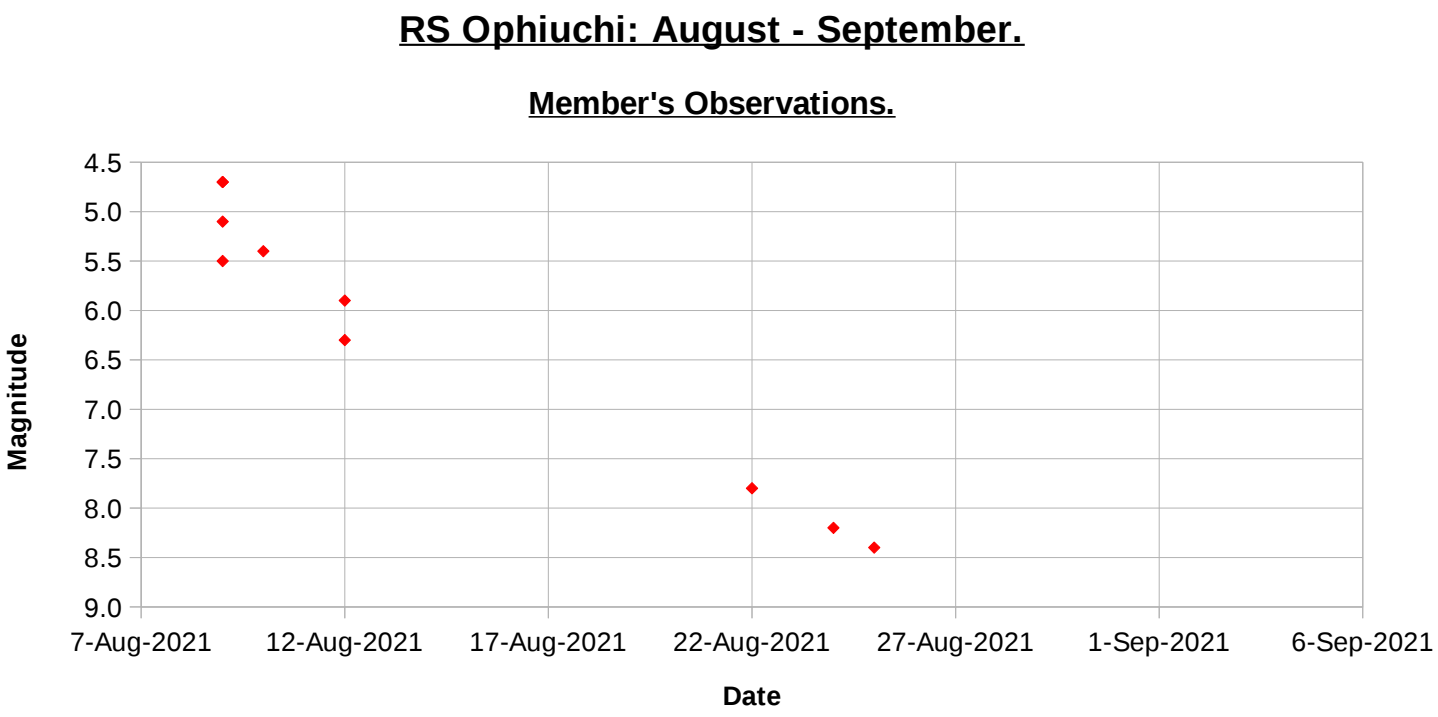
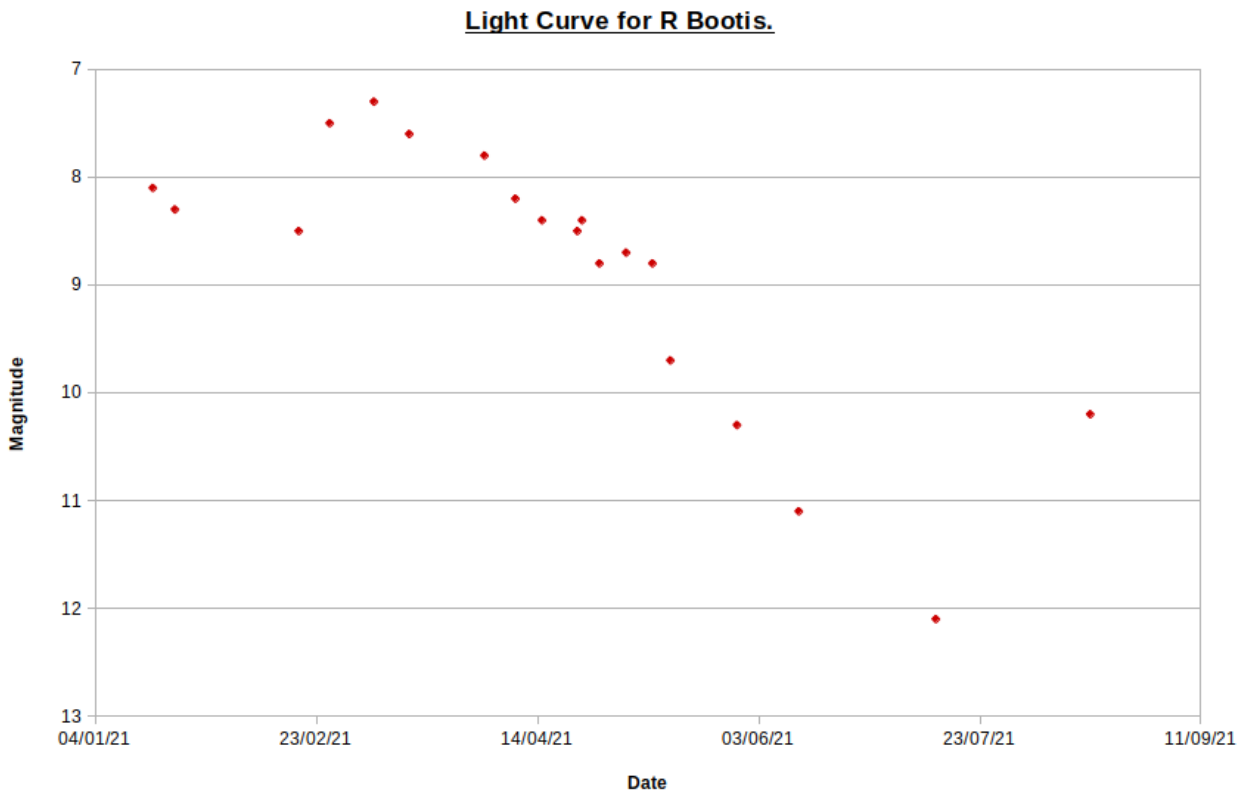


Image of RS Ophiuchi by Robin Scagell.

R Bootis.

Star	Extreme Range	Period	Type
R Boo	7.2 – 12.3	224d	Mira

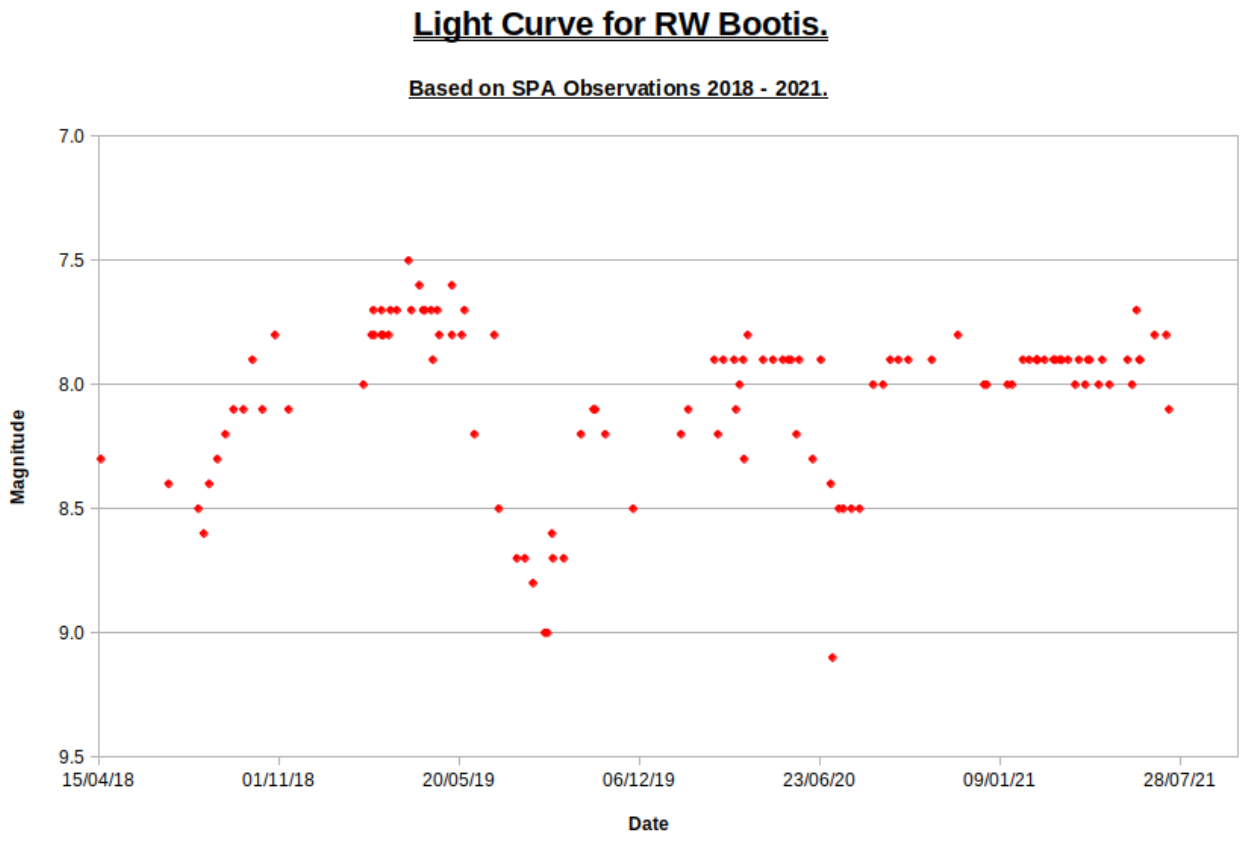


R Bootis is one of our least popular long-period variables. However, members observed R Bootis reaching maximum brightness in March of 2021. Our members also continued to observe R Bootis as it fell to minimum during July 2021.

RW Bootis.

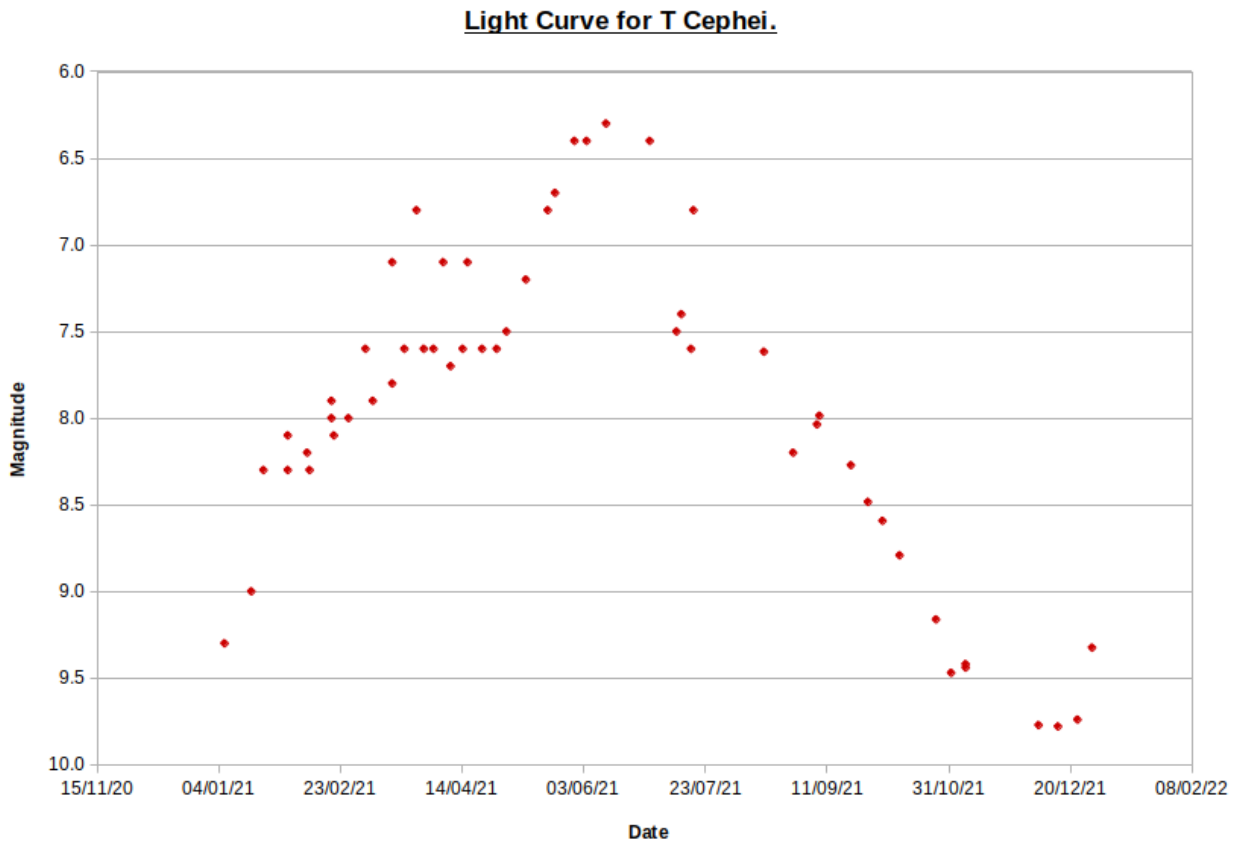
Star	Extreme Range	Period	Type
RW Boo	7.4 – 8.9	209d	Semi-Regular

RW Bootis is a popular variable star, which members have been observing regularly over the course of several years. The graph below shows the star's behaviour since 2018. There is a suggestion that RW Bootis may have a period closer to a year, then the suggested period of 209 days. RW Bootis reached minimum during August 2018, August 2019 and July 2020. RW Bootis wasn't observed over the course of summer 2021, so it wasn't possible to state when it reached minimum, however, it will be interesting to see when RW Bootis reaches minimum brightness this year.



T Cephei.

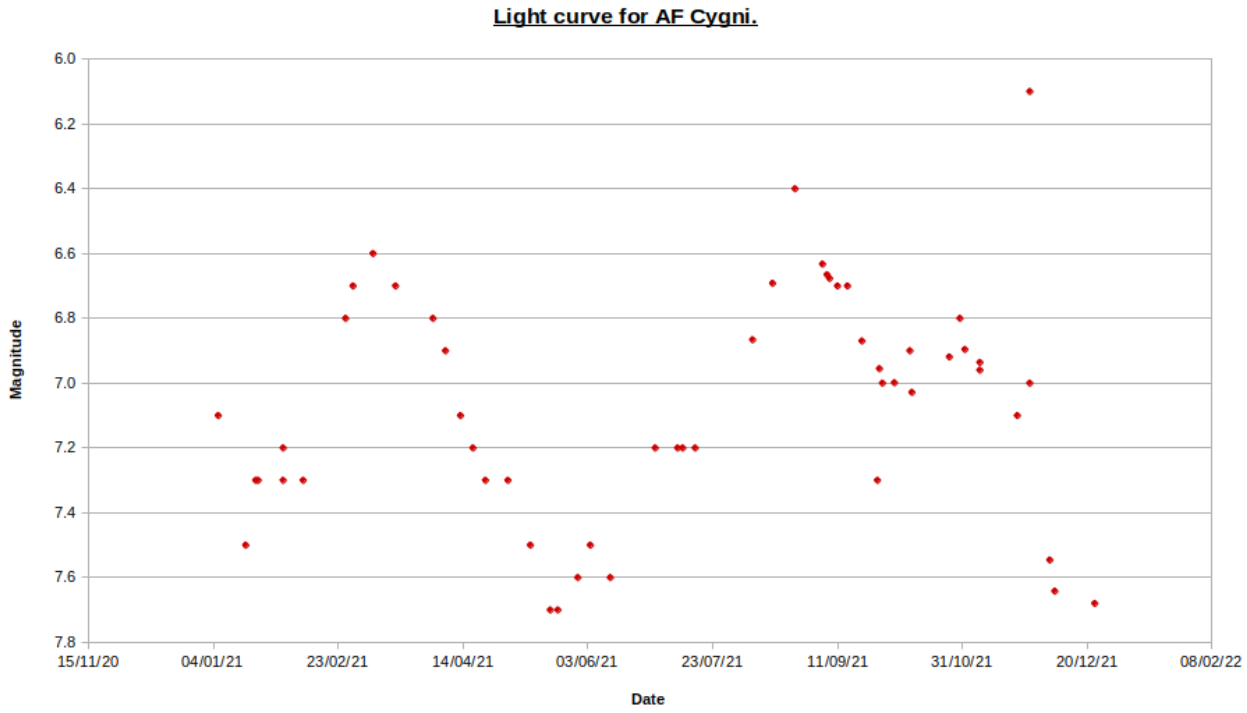
Star	Extreme Range	Period	Type
T Cep	6.0 – 10.3	388d	Mira



T Cephei is a popular Mira variable, properly because it is a relatively bright star. Even at its faintest, T Cephei is only just below tenth magnitude, so can be seen with large binoculars, or a small telescope. As is usual with T Cephei, there is a slow rise to maximum, with a characteristic pause, followed by a rapid decline to minimum.

AF Cygni.

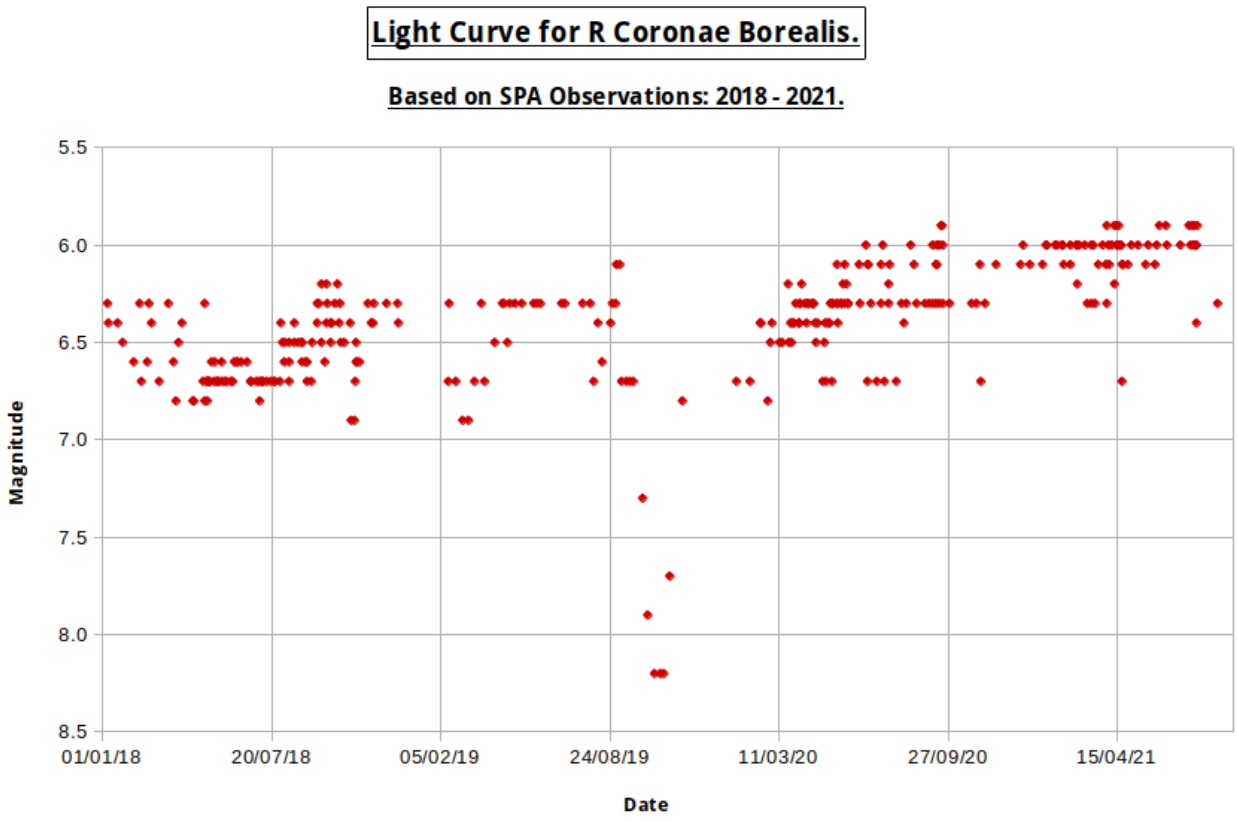
Star	Extreme Range	Period	Type
AF Cyg	6.4 – 8.4	92d	Semi-Regular



AF Cygni was observed over the course of two cycles of variation during 2021. The second decline, during the autumn of 2021, shows an interesting second hump.

R Corona Borealis.

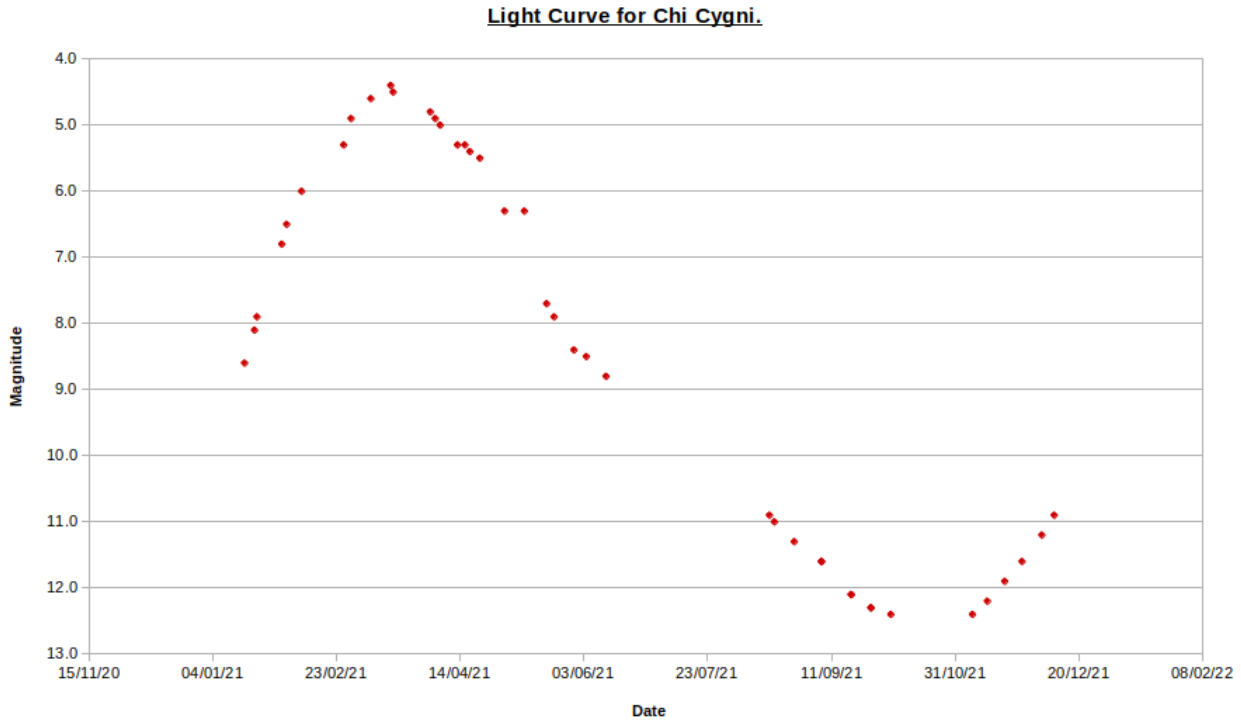
Star	Extreme Range	Period	Type
R CrB	5.8 – 15.0	None	R CrB



R Corona Borealis was regularly observed over the course of 2021. However, R CrB is still oscillating between magnitude 6.0 – 6.5, and has yet to undergo any rapid drops in brightness. As always, it will be interesting to see how R Corona Borealis behaves over the course of 2022.

Chi Cygni.

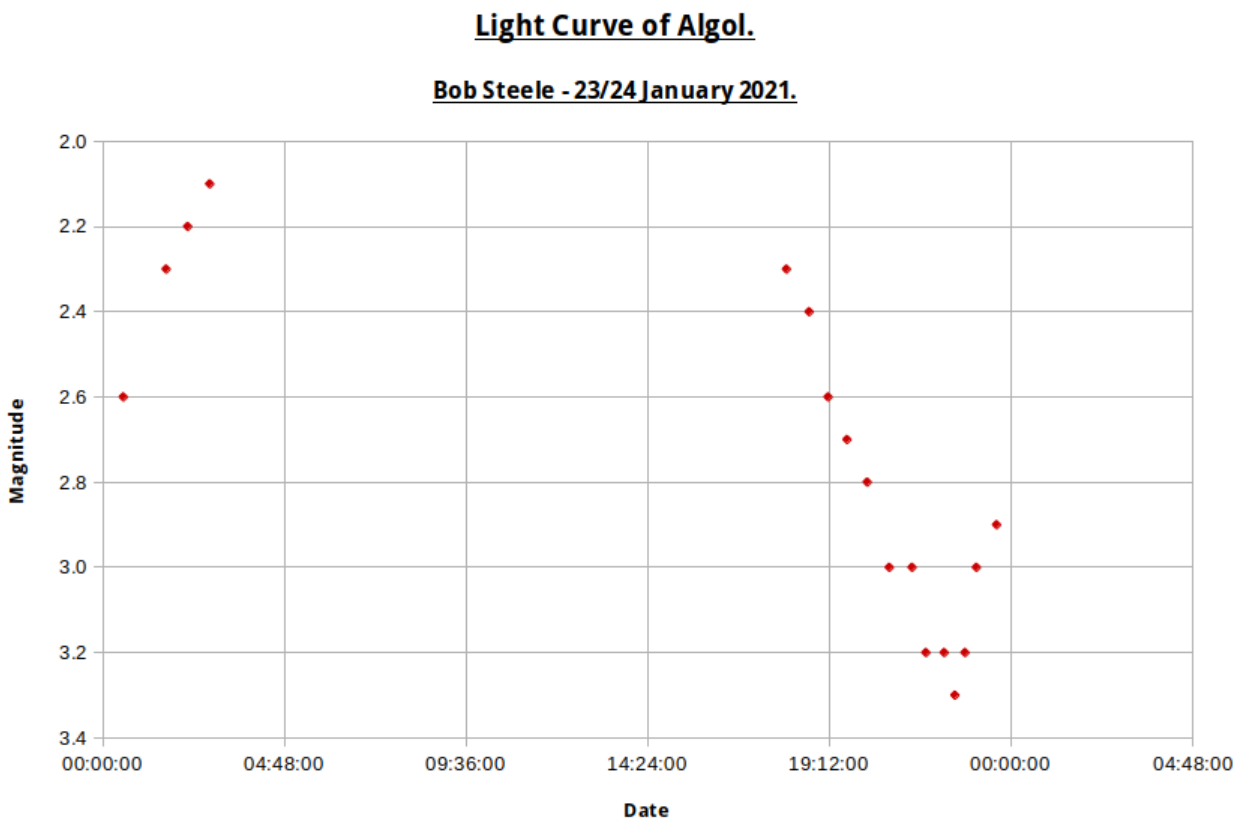
Star	Extreme Range	Period	Type
Chi Cyg	5.2 – 13.4	408d	Mira



Chi Cygni was observed over the course of a single cycle of variation. Chi Cygni reached a typical maximum brightness of around 5.2. Chi Cygni was observed as it fell to minimum brightness in the autumn, and it is due to rise back to maximum in the spring of 2022

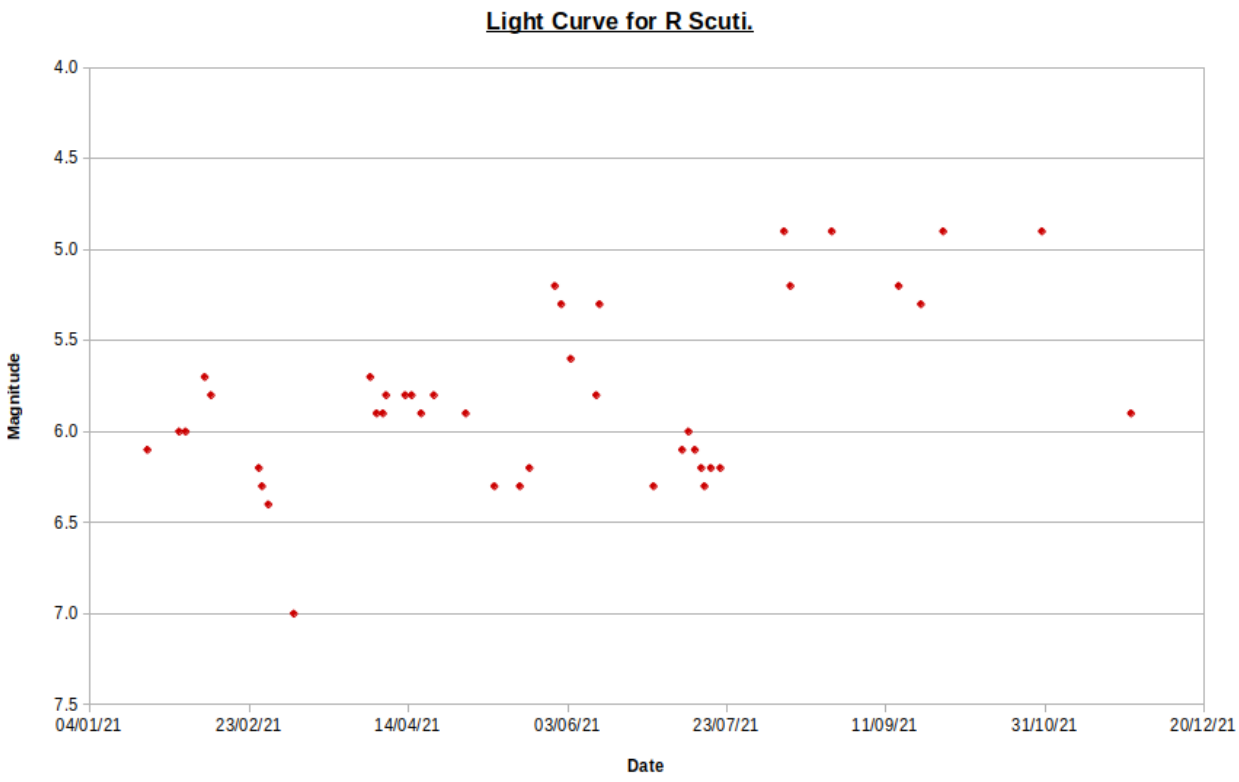
Beta Persei.

Star	Extreme Range	Period	Type
Algol	2.1 - 3.4	2.867d	Eclipsing



R Scuti.

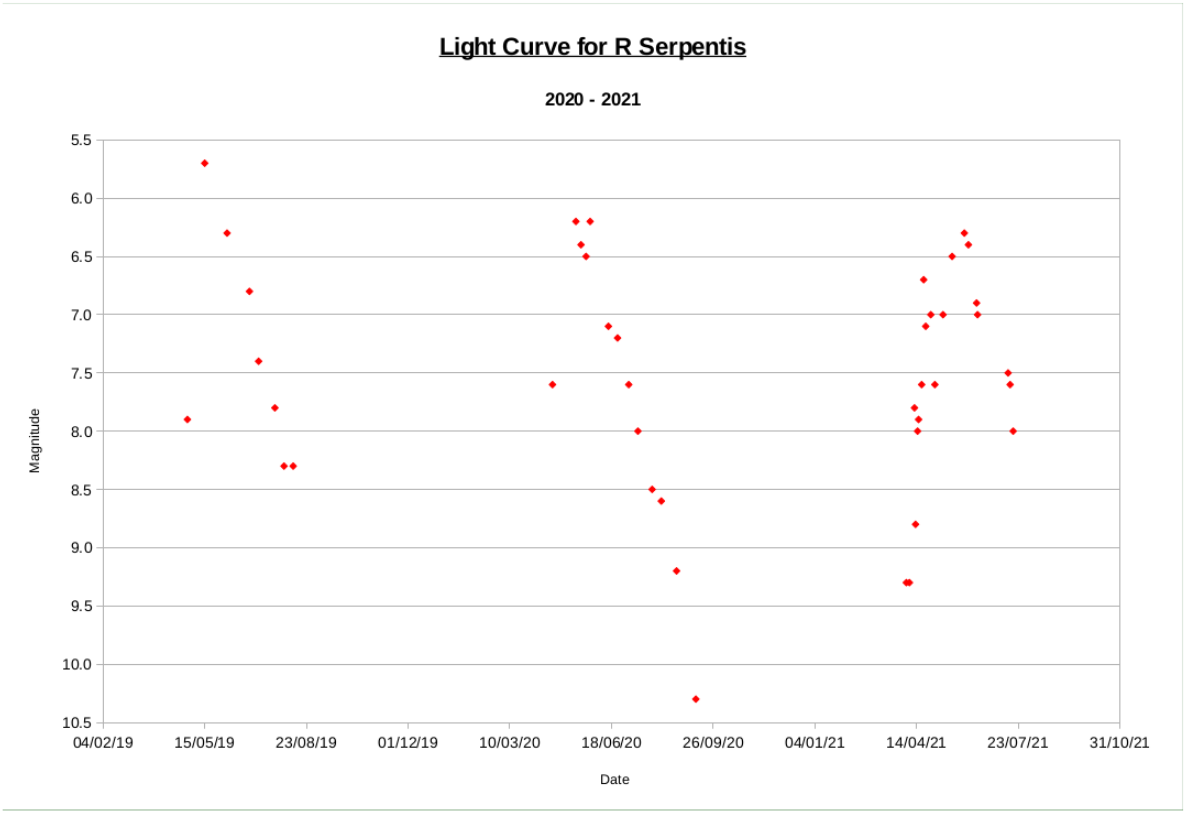
Star	Extreme Range	Period	Type
R Sct	4.5 – 8.6	142d	R Sct



R Scuti once again showed the usual amount of chaotic behaviour we've come to expect from it. It seems to oscillate between about magnitude 6.5 and magnitude 5.0, with a general increase in brightness towards the end of the year.

R Serpentis.

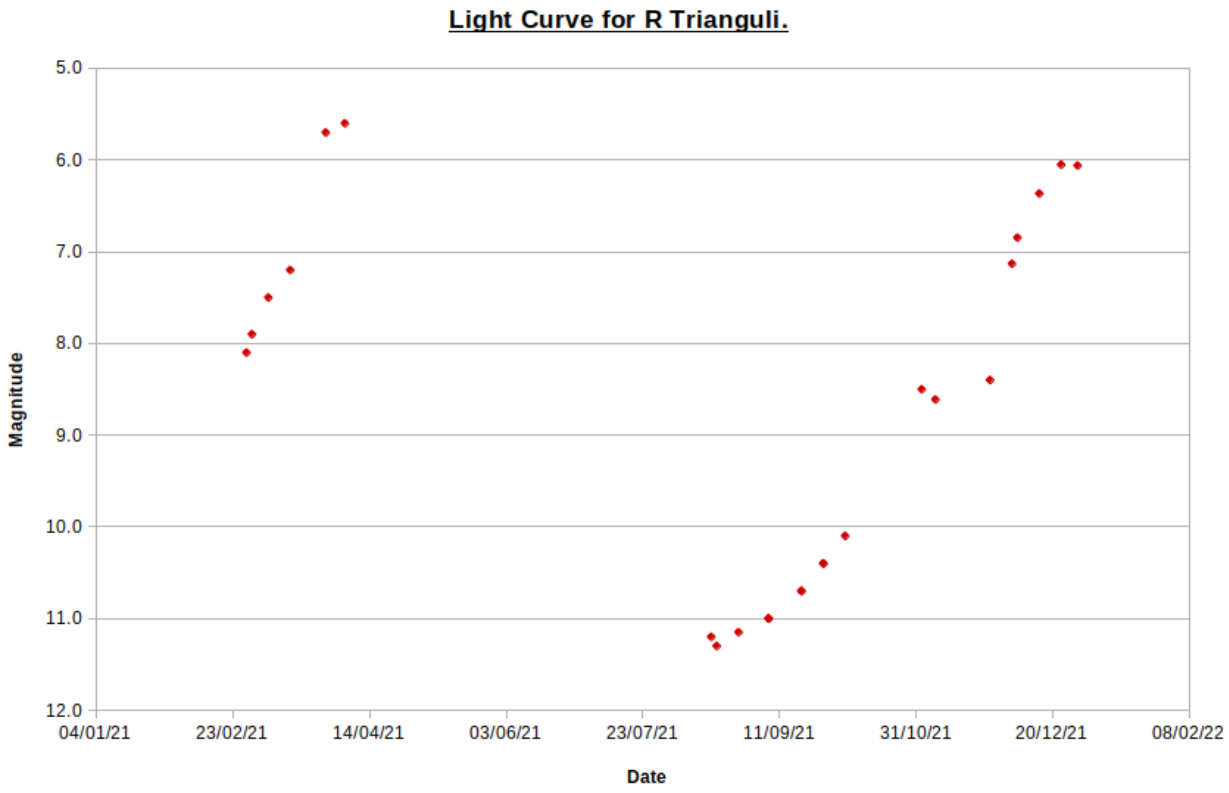
Star	Extreme Range	Period	Type
R Ser	6.8 – 13.4	357d	Mira



R Serpentis was observed over the course of a single variation during 2021.

R Trianguli.

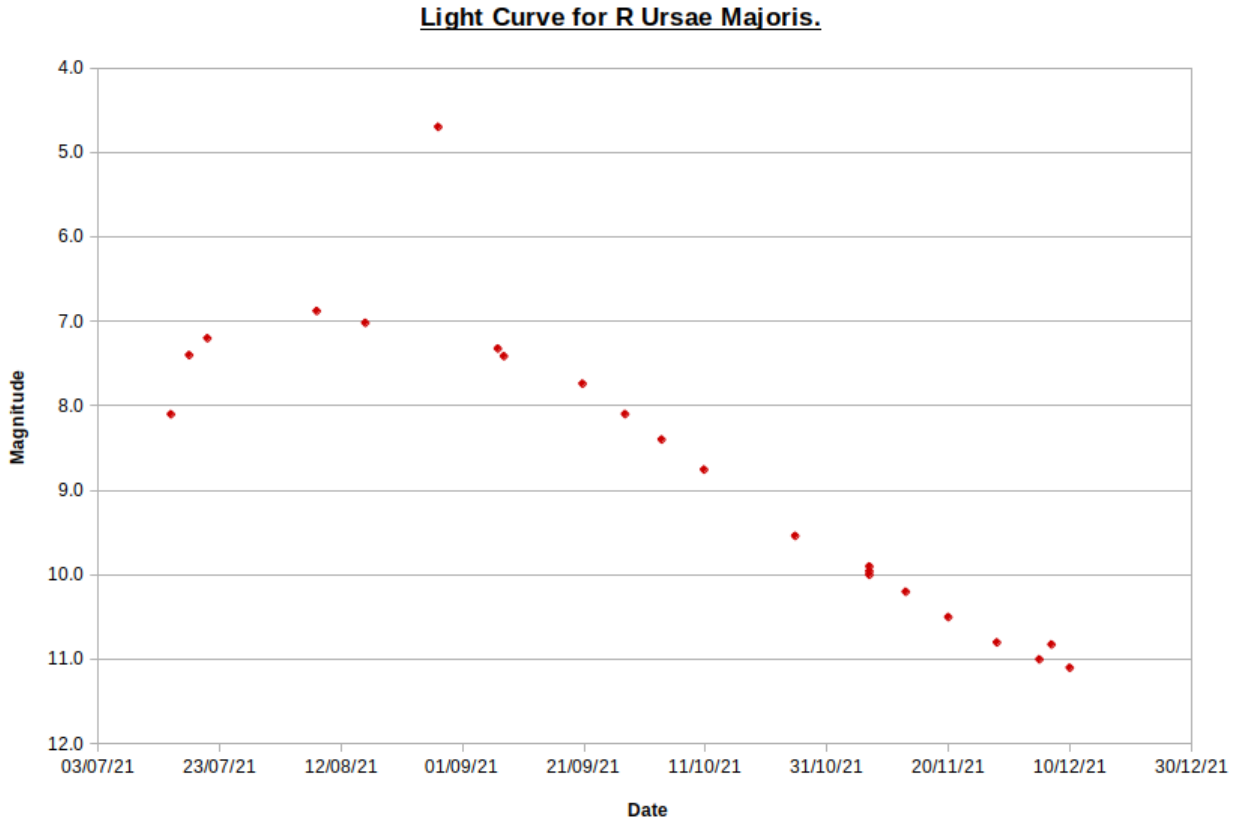
Star	Extreme Range	Period	Type
R Tri	6.2 – 11.7	267d	Mira



R Trianguli was observed as it approached maximum brightness towards the end of the year. It seems that R Trianguli reached a typical maximum of 6.0.

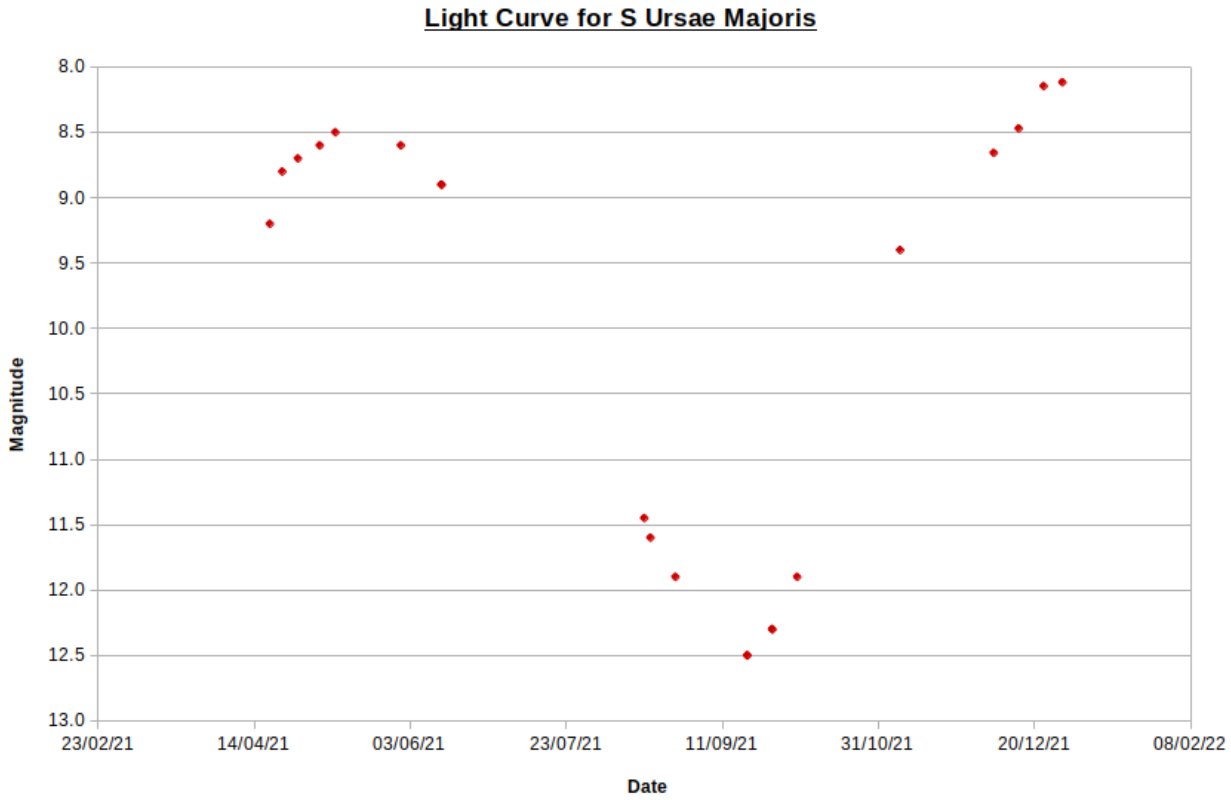
R Ursae Majoris.

Star	Extreme Range	Period	Type
R UMa	7.5 – 13.0	302d	Mira



S Ursae Majoris.

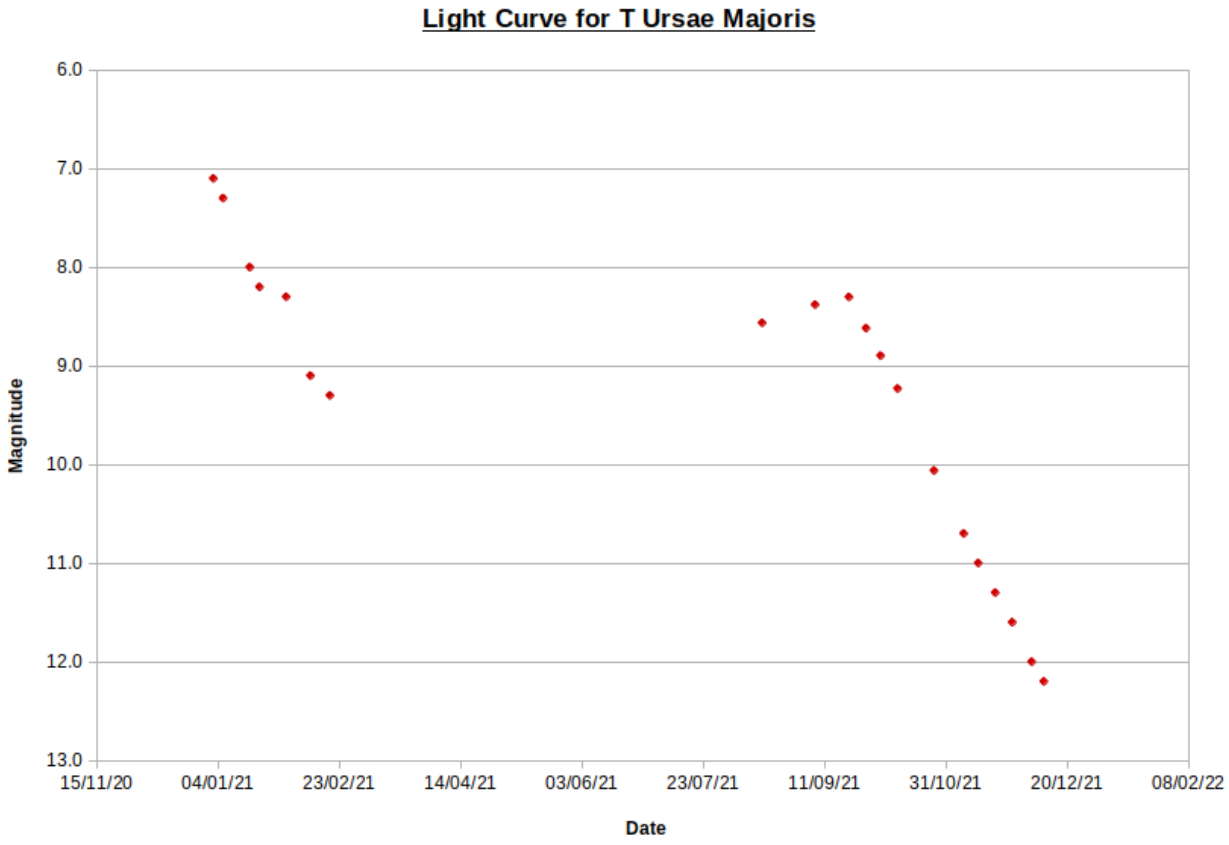
Star	Extreme Range	Period	Type
S UMa	7.8 – 11.7	226d	Mira



All of the three long-period variables stars, in the constellation of Ursa Majoris, that are on the SPA program were observed by the SPA members. S Ursa Majoris reached a normal maximum of around 8.0, but reached a low minimum of 12.5. T Ursae Majoris showed more typical behaviour, with the star reaching a typical maximum of jut under magnitude eight. Whereas, R Ursa Majoris showed both a relatively bright maximum, of around seven, and a relatively bright minimum of around 11.

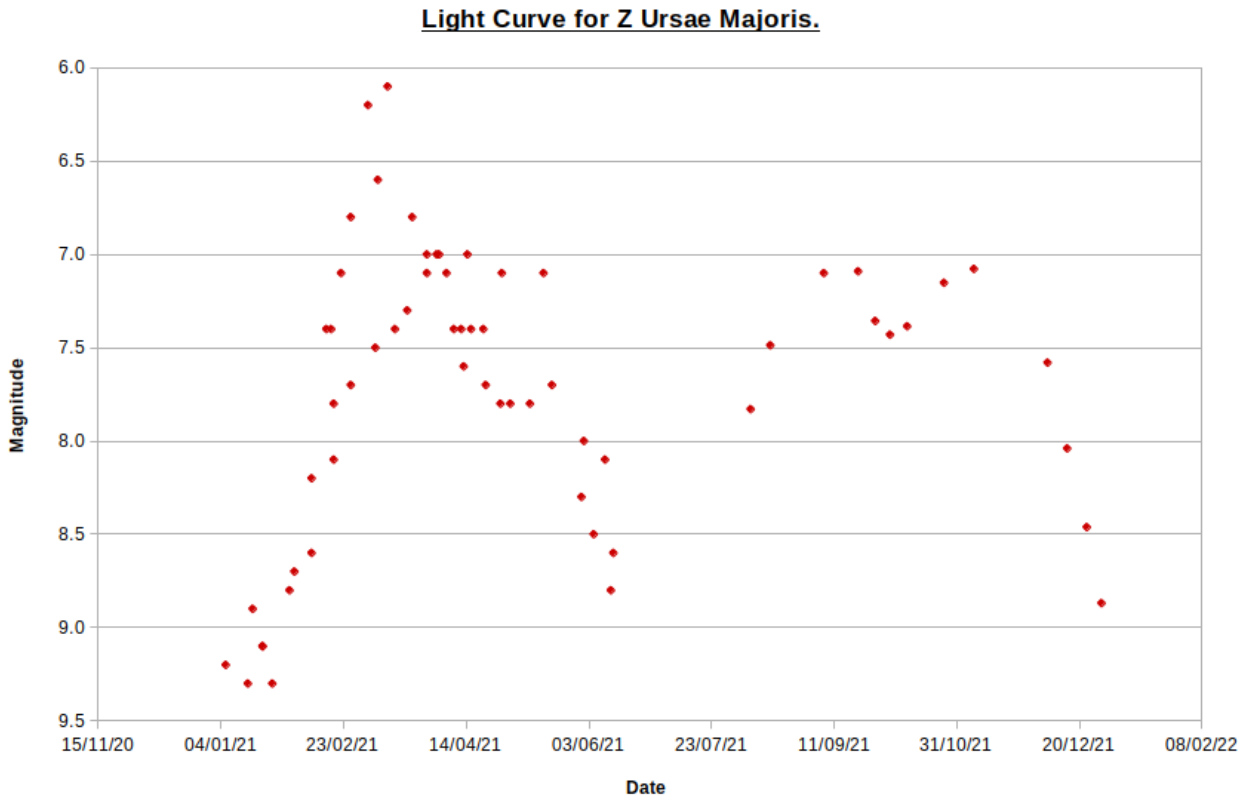
T Ursae Majoris.

Star	Extreme Range	Period	Type
T UMa	7.7 - 12.9	257d	Mira



Z Ursae Majoris.

Star	Extreme Range	Period	Type
Z UMa	6.3 – 9.6	195d	Semi-Regular



RY Draconis.

Star	Extreme Range	Period	Type
RY Dra	6.0 – 8.0	200d?	Semi-Regular