ASASSN-24fw in the context of long and deep stellar dimmings in time-domain surveys

CCAPP Symposium 2025

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September 17, 2025

ASAS-SN Survey

ASAS-SN Survey

All-Sky Automated Survey for Supernovae

20 14-cm robotic telescopes of located in Hawai‘i, Texas, Chile, and South Africa

Surveys the entire night sky daily since 2012

with about 14 million images collected so far

It’s primary goal is to discover supernova explosions

But a lot more science can be done with this survey:

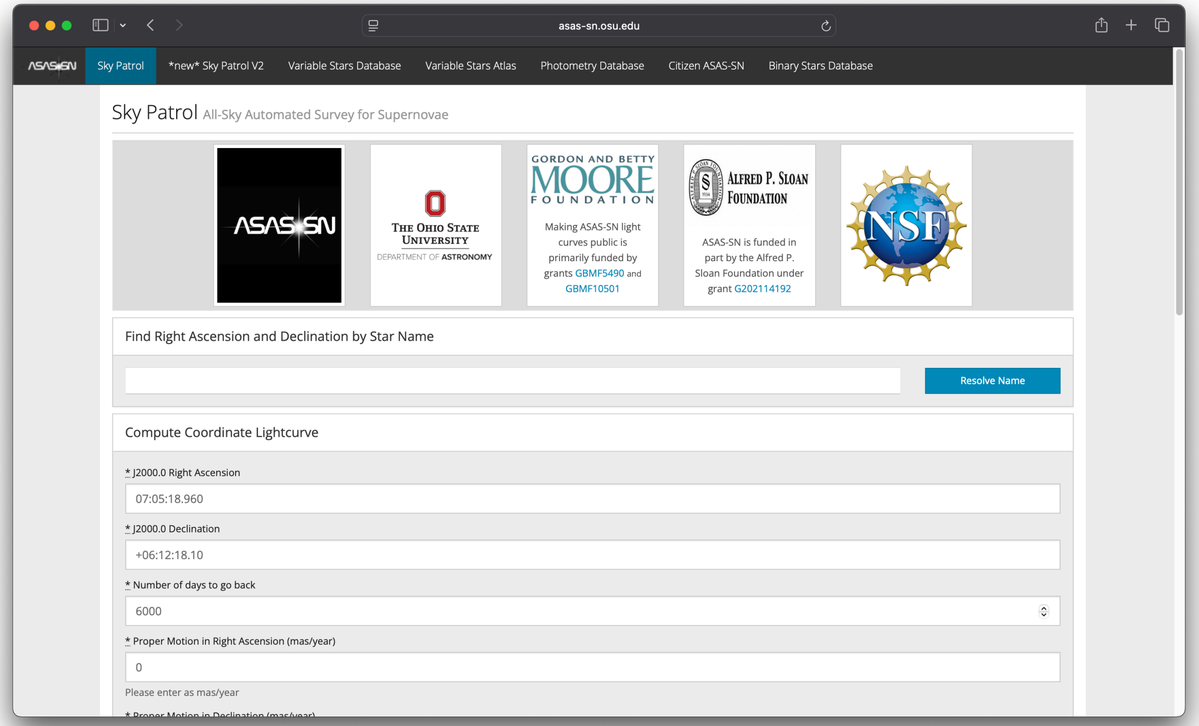
TDEs, AGNs, eclipsing binaries, variable stars, low surface brightness galaxies…

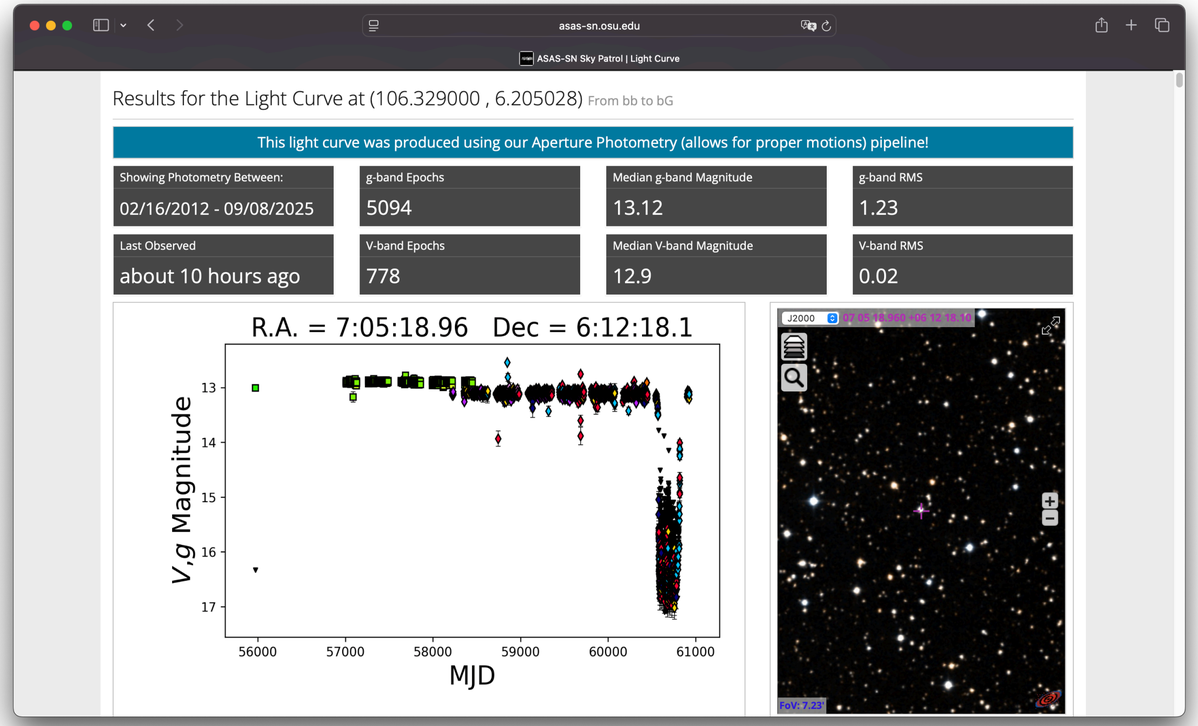
(e.g., Hoogendam et al. 2024, Yuk et al. 2022, Rowan et al. 2022, Christy et al. 2023, Petz et al. 2025, Jennerjahn et al. 2025)

ASAS-SN Survey

All-Sky Automated Survey for Supernovae

All data is publicly available through https://asas-sn.osu.edu/ and http://asas-sn.ifa.hawaii.edu/skypatrol/





ASASSN-24fw

ASASSN-24fw

Discovery and follow-up

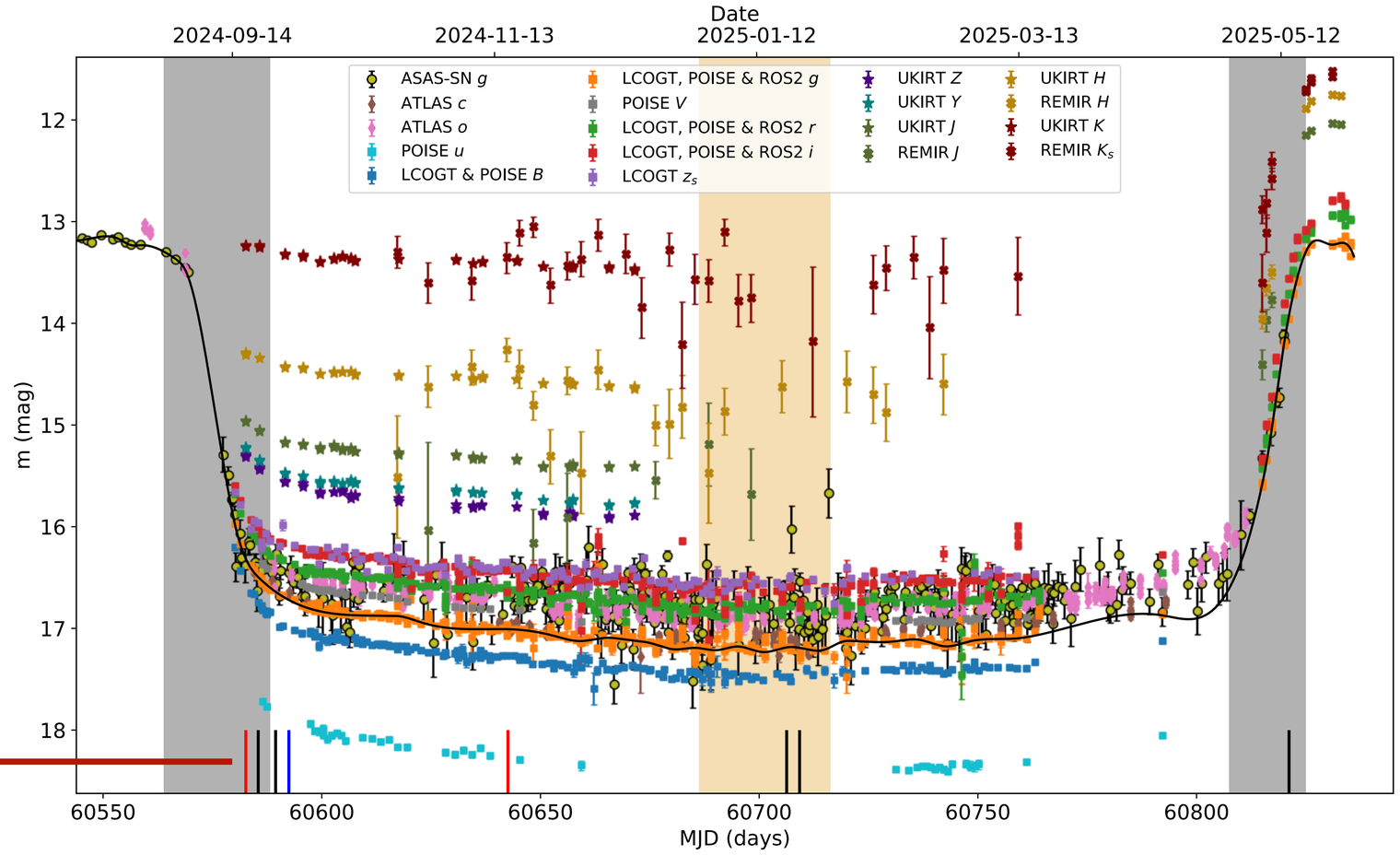
Discovered as part of ASAS-SN normal operations and reported on September 27 2024 in the Astronomer's Telegram

ASASSN-24fw: A Main Sequence Star with a Deep Dimming Event

ATel #16833; *B. JoHantgen, D. M. Rowan, K. Z. Stanek, J. Callahan, C. S. Kochanek, S. A. Petz (OSU), B. J. Shappee (Univ. of Hawaii)*
*on **27 Sep 2024; 21:52 UT***
Credential Certification: Krzysztof Stanek (stanek.32@osu.edu)

Optical and NIR spectra and polarization measurements

Photometric follow-up



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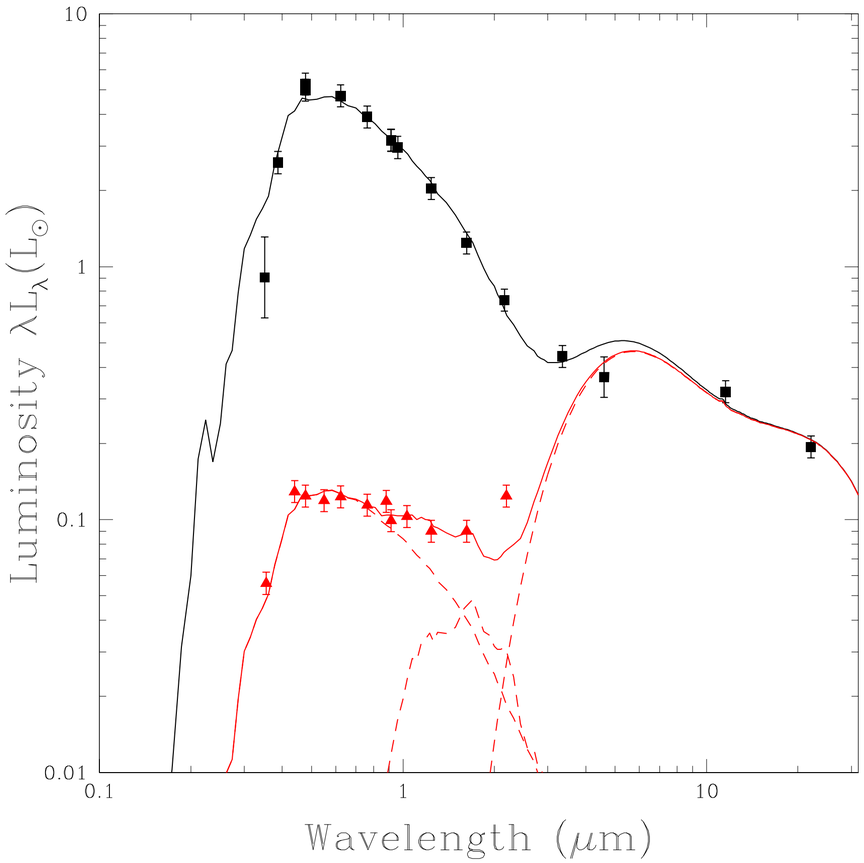
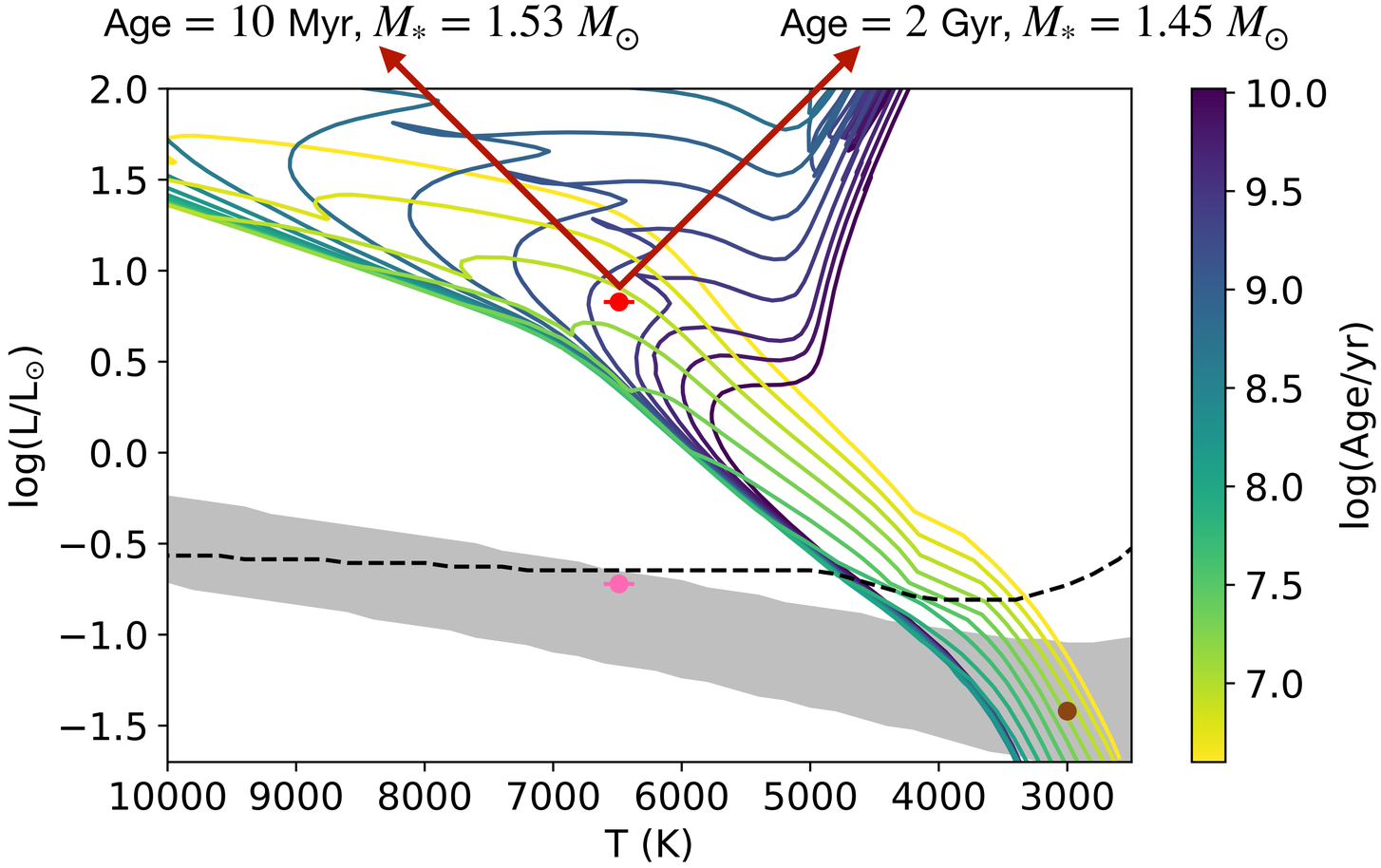
Pre-event SED

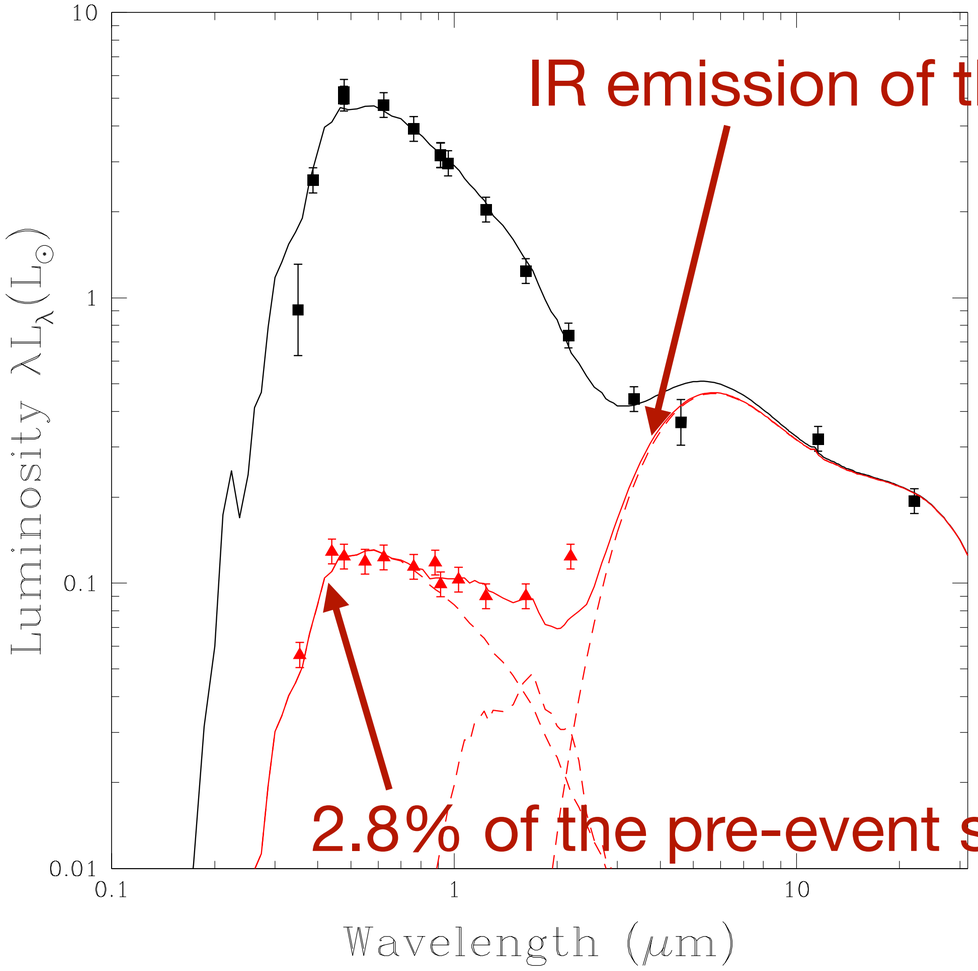


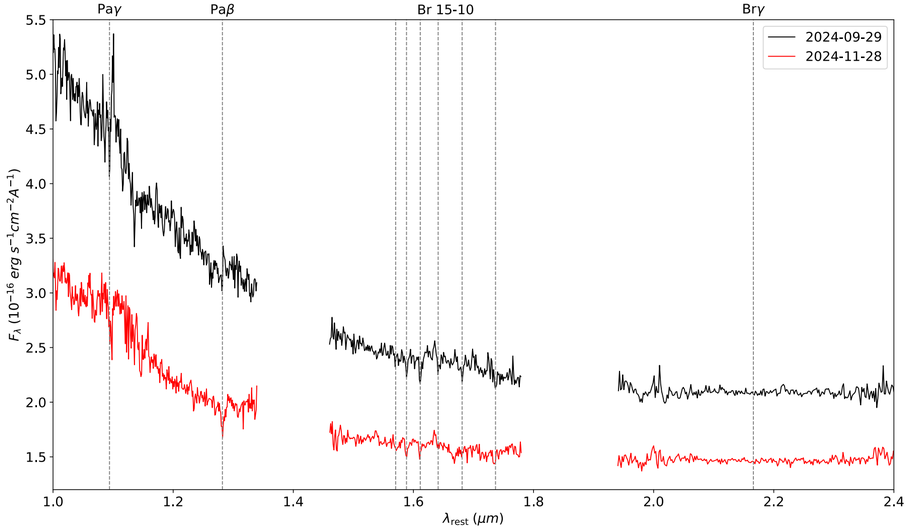


$T_* = 6490 \pm 120\ K, L_* = 6.73 \pm 0.03\ L_\odot, R_* = 2.05 \pm 0.07\ R_\odot, \tau_V = 0.249 \pm 0.017, T_d = 552 \pm 16\ K, R_{d,in} = 1020 \pm 30\ R_\odot$

ASASSN-24fw

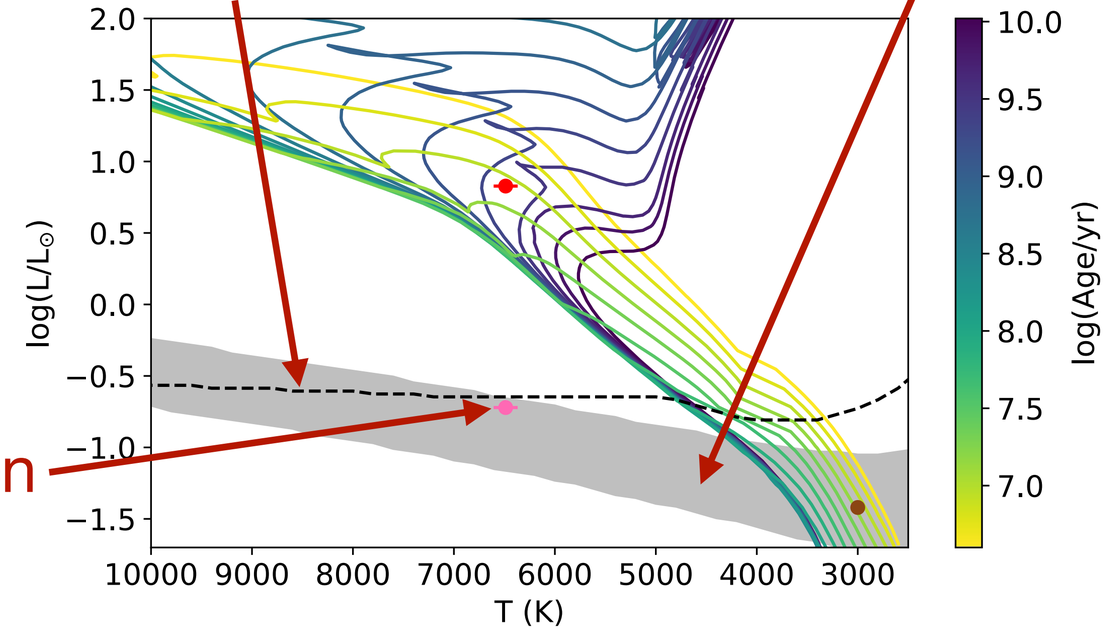
Eclipse SED





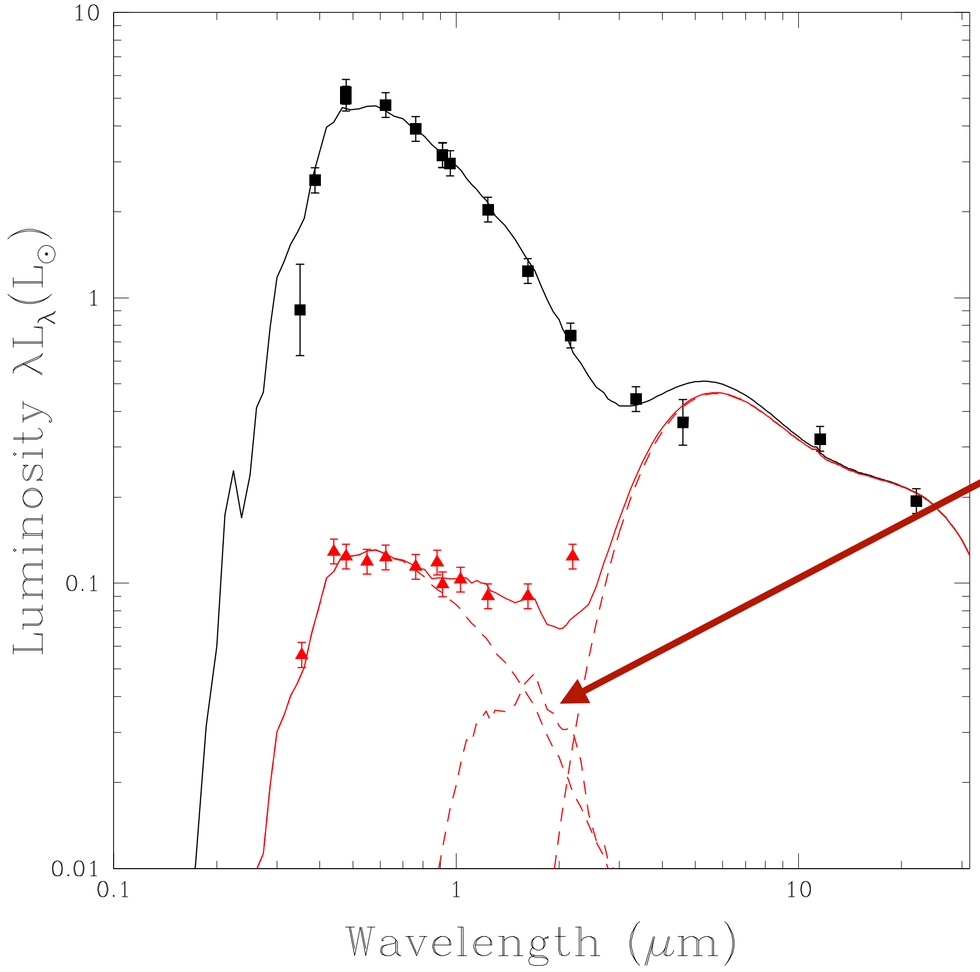
Brγ diluted but Br10-15 not

Optical emission shape unchanged



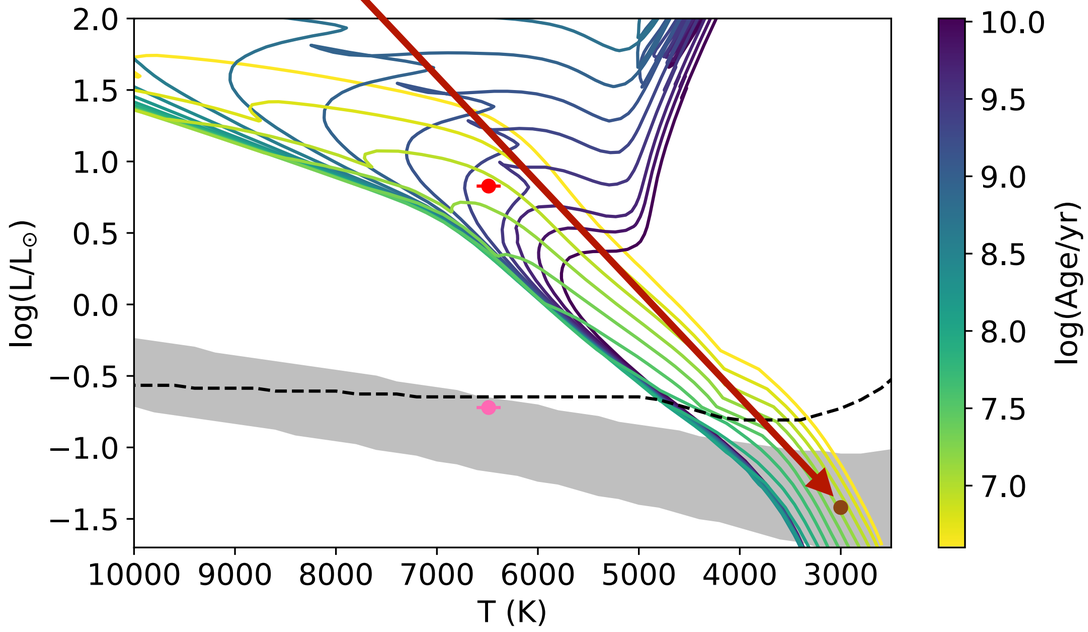
ASASSN-24fw

Eclipse SED



We propose an M star companion

$T_* = 3000\ K, L = 0.038 L_\odot, M = 0.25 M_\odot$



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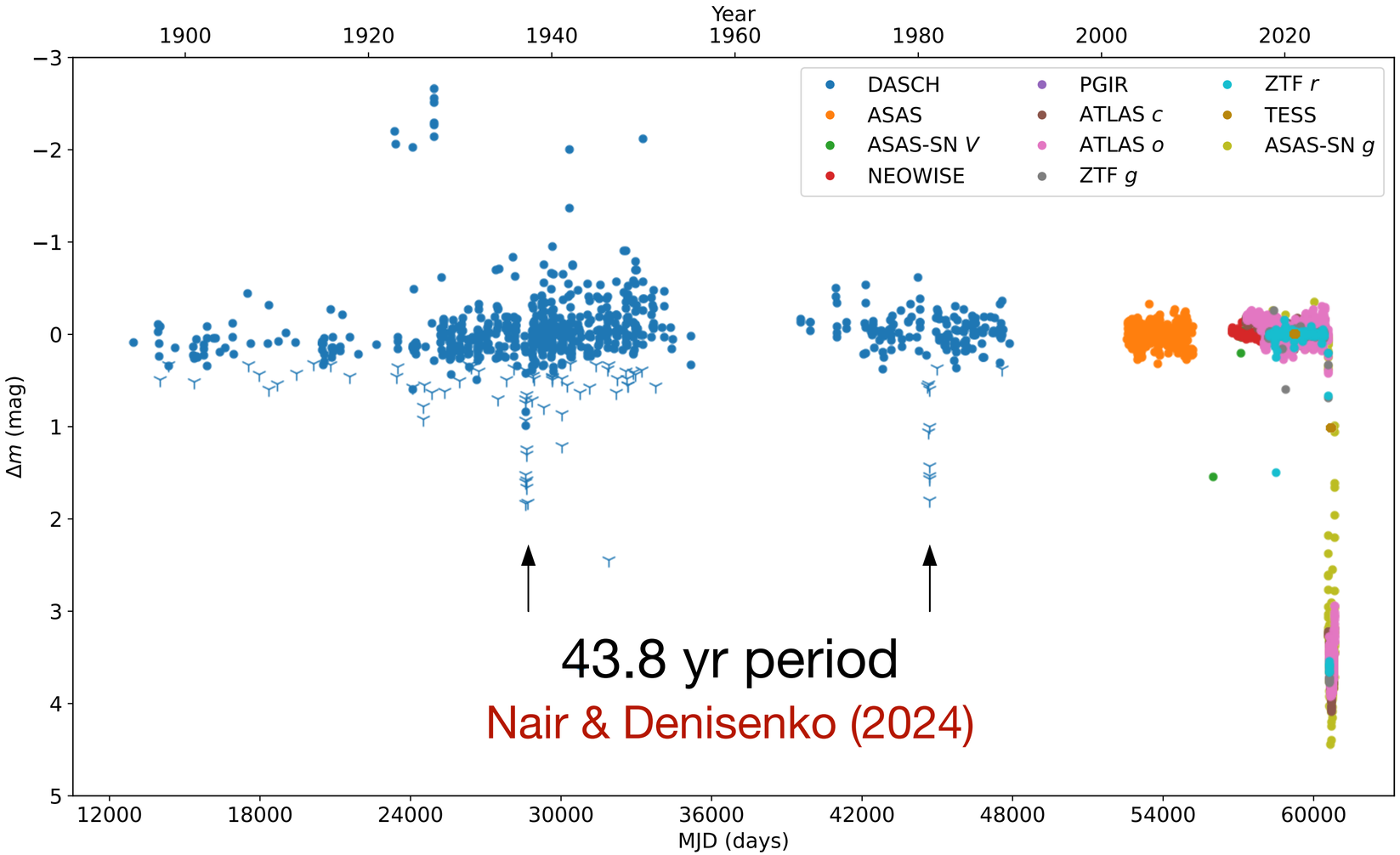
Eclipse periodicity



Evidence of a such a long period thanks to DASCH archival data

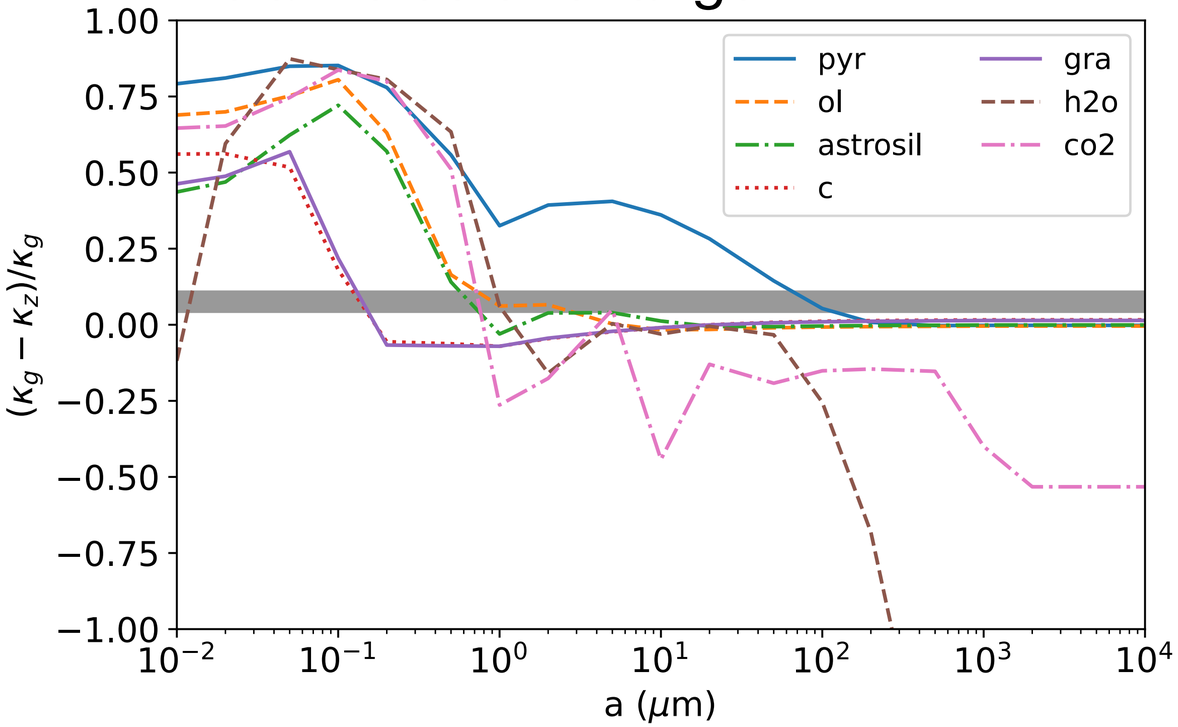
ASASSN-24fw

Nature of the occulter

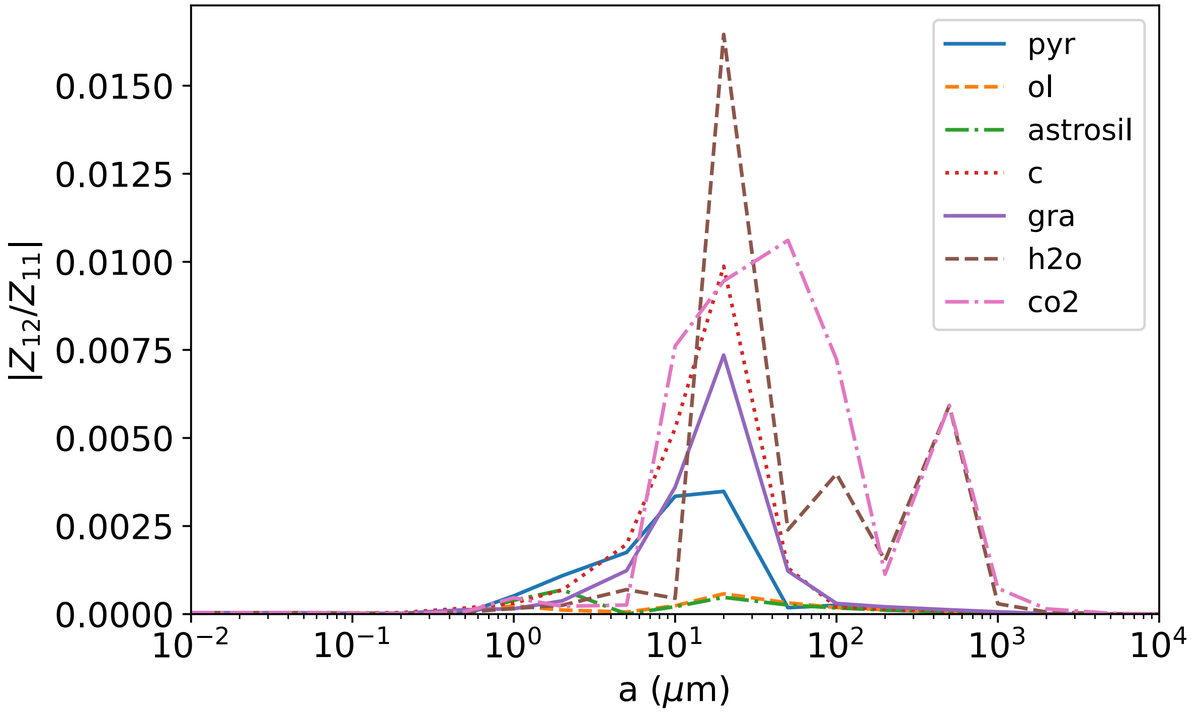
Band	Δm (mag)	$\tau_{\rm min}$	$f_{\rm max}$ (%)
g	4.12±0.02	3.80±0.02	2.24±0.04
r	3.95±0.02	3.64±0.02	2.64±0.06
i	3.80±0.04	3.50±0.03	3.01±0.10
z	3.76±0.05	3.47±0.05	3.13±0.15
J	3.39±0.04	···	···
H	2.84±0.03	···	···
K_s	1.9±0.4	···	···

+ up to 4% of polarization

Relative color change:



Ability to polarize:

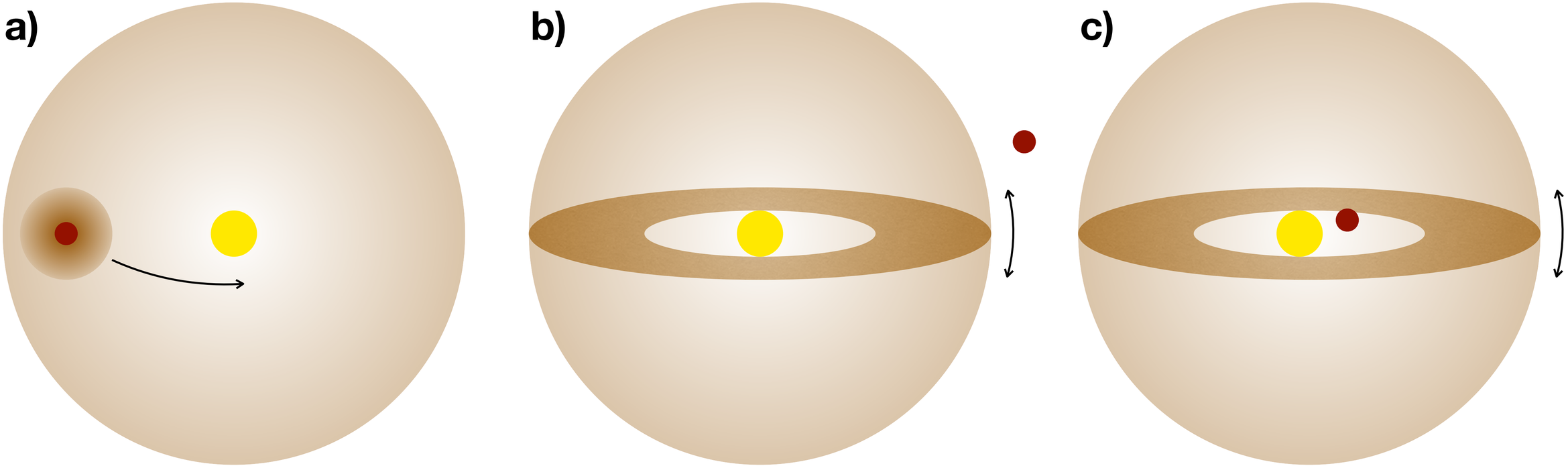


Evidence of large grains in: protoplanetary disks, extended rings, and old collisions

ASASSN-24fw

System geometry

An F-type star, a smaller star (M-type likely) and an optically thick structure



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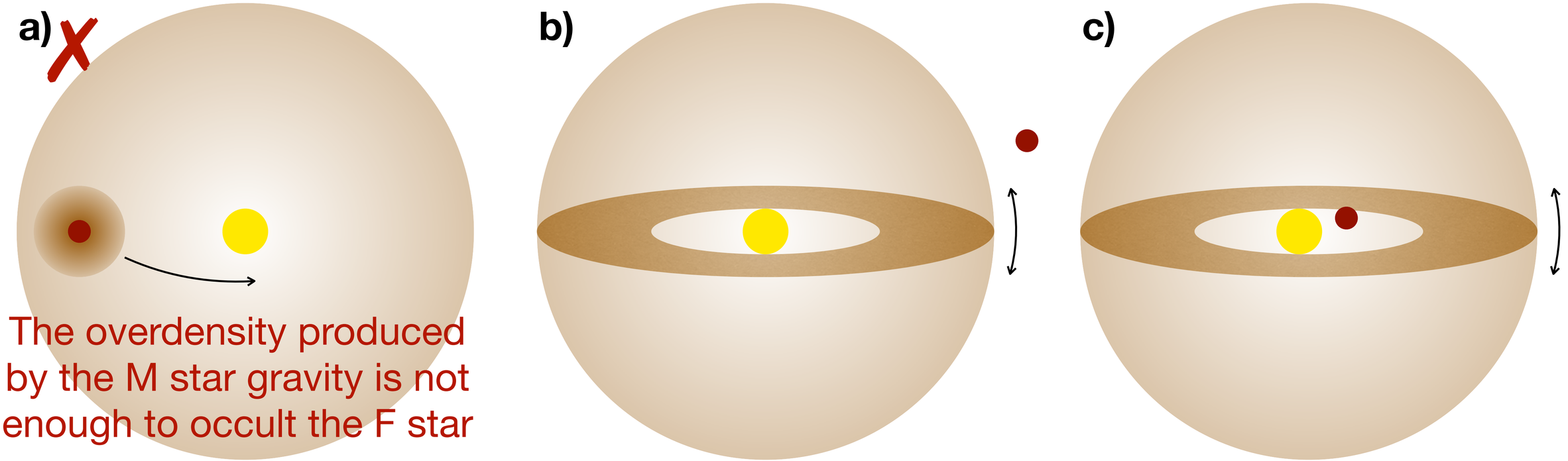

The overdensity produced by the M star gravity is not enough to occult the F star

ASASSN-24fw

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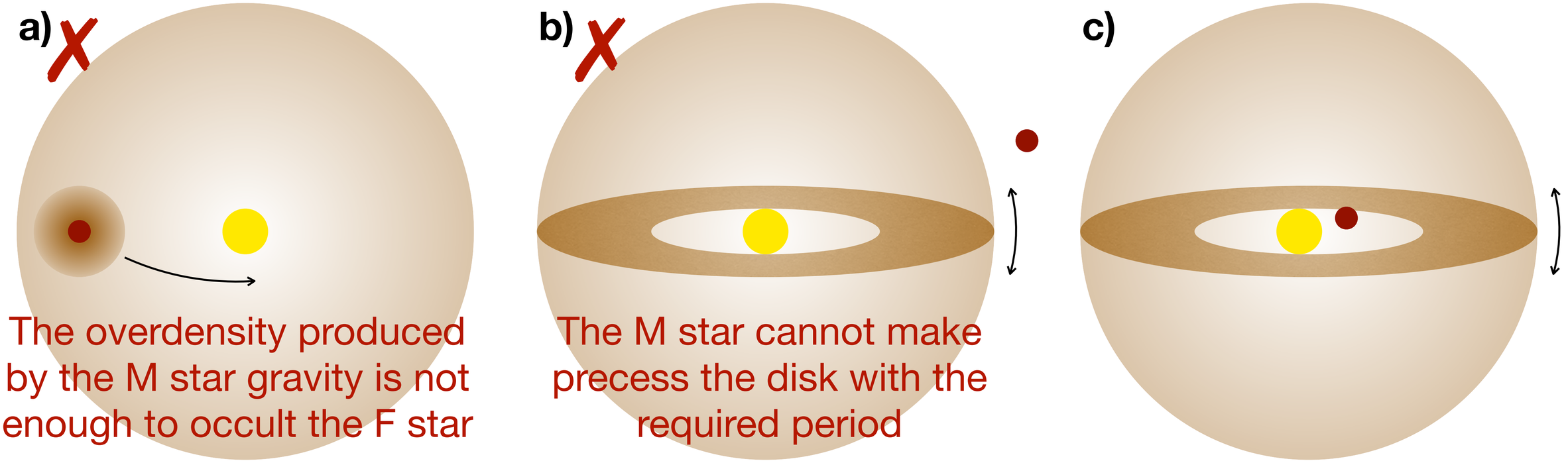


The overdensity produced by the M star gravity is not enough to occult the F star

The M star cannot make precess the disk with the required period

Properties of long and deep eclipses

Long and deep eclipses

Survey of 47 systems

"Long and deep":

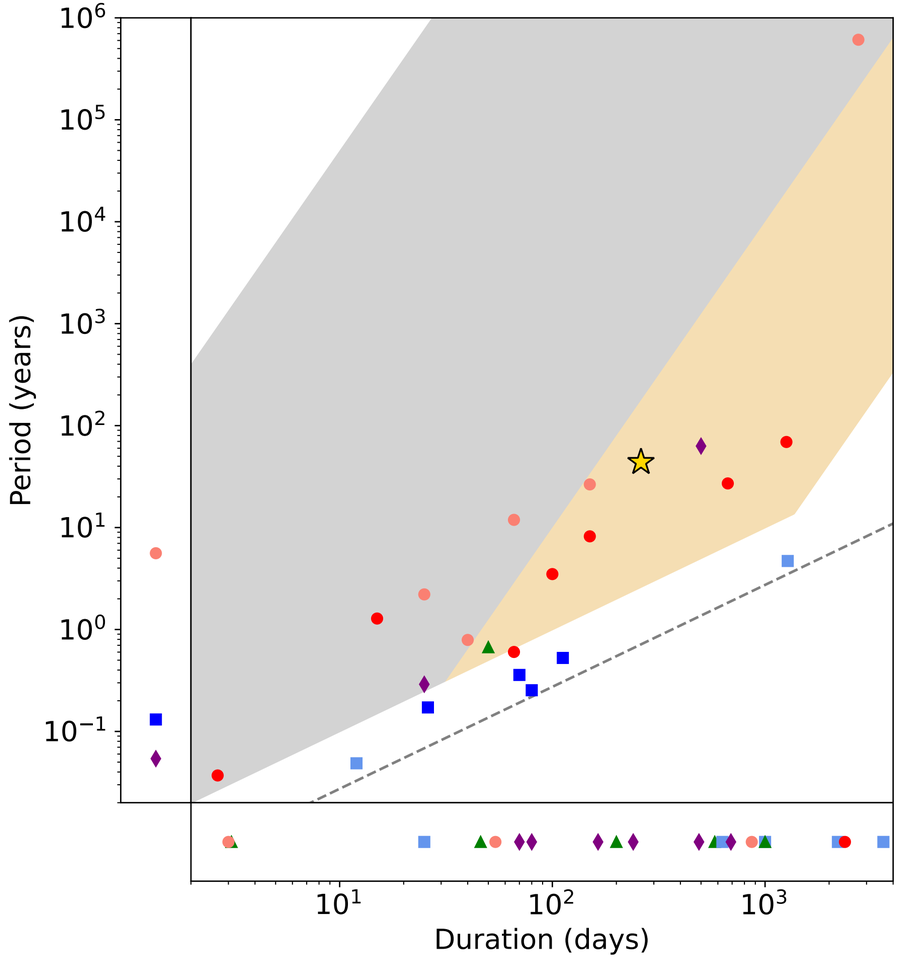
Duration > 1 day

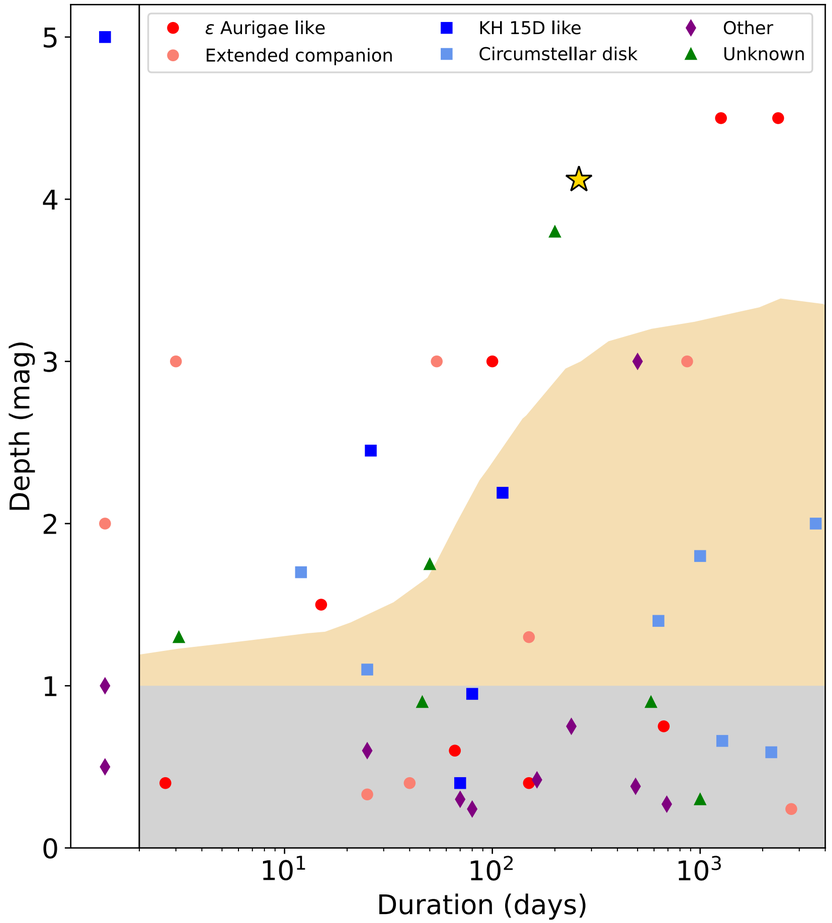
Flux decrease > 20%

Name	*Gaia* DR3 ID	Distance (pc)	$E(B-V)$ (mag)	Duration (days)	Period (years)	Depth (mag)	References
OGLE-LMC-ECL-17782	4658430243457185664			2.67	0.037	0.4 in I	(1)
ASASSN-V J213939.29−702817.3	6396259296582909440	1053^{+11}_{-15}	0.026	3.1	Unknown	∼1.3 in g	(2)
CHS 7797	No *Gaia* ID			∼12	0.0487	∼1.7 in R, I, and z'	(3)
OGLE-LMC-ECL-11893	4658294458116546304	7500^{+2600}_{-1500}	0.920	∼15	1.281	Irregular, up to 1.5 in I	(4)
PDS 110	3220462655745525632	343±3	0.115	25	2.21	0.33 in V	(5)
EPIC 204278916	6243130106031671168	139.6±0.4	0.000	∼25	Unknown	Irregular, up to 1.1 in Kepler band	(6)
Bernhard-2	3048281986701404160	2900^{+1300}_{-500}	0.301	26	0.172	2.45, 2.12, 1.85, 1.54, 1.57 in $g/r/i/z/y$	(7)
VVV-WIT-07	5974962995291907584	5200^{+2200}_{-1800}	2.118	∼50	0.46 or 0.88 (tentative)	1.75 in NIR	(8)
V1400 Cen	6117085769513415168	137.9±0.2	0.024	∼54	Unknown	Irregular, up to 3 in V	(9)
ASASSN-21co	6647970630972147840	2660^{+130}_{-110}	0.109	66	11.9	0.6 in V	(10)
ELHC 10	4658166433748357760	18000^{+5000}_{-4000}	1.139	∼66	0.602	∼0.6 in I	(11)
VSSG 26	No *Gaia* ID			∼70	0.3583	0.4 in K_s	(12)
YLW 16A	No *Gaia* ID			∼80	0.2536	0.95 in K_s	(13)
OGLE-BLG182.1.162852	No *Gaia* ID			100	3.496	Variable, between 2 to 3 in I	(14)
Bernhard-1	2061078599753657728	2300^{+500}_{-400}	0.780	112	0.526	2.19, 2.12, 1.53, 1.47, 1.46 in $g/r/i/z/y$	(7)
η Geminorum	3377072212924335488			150	8.2	0.4 in V	(15)
V773 Tau	163184366130809984	119±2	0.000	150	26.5	1.3 in V	(16)
WD J1237+5937	1578454838386128384	193±16	0.000	164	Unknown	0.42 achromatic	(17)
VVV-WIT-08	4044152029396602880	8500±1600	0.633	∼200	Unknown	3.8 achromatic	(18)
ASASSN-24fw	3152916838954800512	1011^{+15}_{-23}	0.062	261	43.8 (suggested)	4.12, 3.95, 3.81, 3.76, 3.39, 2.84, 1.9 in $g/r/i/z_s/J/H/K_s$	This work, (19)
WD J1013−0427	3780094656734582528	304^{+10}_{-12}	0.035	489	Unknown	0.38, 0.27, 0.20, 0.20 in ZTF g/ATLAS c/ZTF r/ATLAS o	(17)
ASASSN-21qj	5539970601632026752	557±3	0.364	∼500	63 (predicted)	Irregular, up to ∼3 in g	(20)
ASASSN-V J060000.76−310027.83	2891196718939580672	$155.8^{+0.3}_{-0.2}$	0.000	∼580	Unknown	0.9 in g	(21)
V409 Tau	150393571269837184	129.5±0.4	0.000	$\lesssim$630	Unknown	∼1.4 in V	(22)
ε Aurigae	205499655242974464	1060^{+370}_{-190}	0.018	∼668	27.1	∼0.75 achromatic	(23)
WD J1302+1650	3937407901354145536	400^{+17}_{-14}	0.000	691	Unknown	0.27 achromatic	(17)
Gaia21bcv	3045209156636885760	1360±80	0.981	866	Unknown	Irregular, up to 3 in *Gaia* G and ZTF r	(24)
M 2-29	4063244773875284224	6600^{+1900}_{-900}	0.521	∼1000	Unknown	1.3 in I, 1.7-1.8 in V	(25)
TYC 2505-672-1	7951883914208888192	1370^{+30}_{-40}	0.000	1260	69.1	4.5 in the optical	(26)
V718 Per	216678115082741248	307±3	1.874	1278	4.7	0.66 in I	(27), (28)
J202402+383938	2061158279988516224	1830±50	0.653	2200	Unknown	0.59 in g	(29)
Gaia17bpp	1824311891830344704	8500^{+2300}_{-1700}	1.312	2374	Unknown	4.5 in *Gaia* G	(30)
ASASSN-21js	5334823481651325440	2610^{+100}_{-90}	0.385	Ongoing, 2746 (predicted)	610000 (predicted)	0.24 in g	(31)
ASASSN-24fa	5697179770616369664	4800±300	0.187	Ongoing, >1220	Unknown	0.3 in g	(32)
AA Tau	147818450613367424	$133.3^{+2.3}_{-1.4}$	0.000	Ongoing, >5300	Unknown	Irregular, up to ∼2 in V	(33)
WeSb 1	4233849610803444960	3200^{+300}_{-200}	0.239	Variable, few days	Aperiodic, 1 (tentative)	Irregular, up to 3 achromatic	(34), (35)
"Tabby's Star"	2081900940499099136	$434.3^{+1.7}_{-2.0}$	0.314	Variable, between 5 to 80	Aperiodic	Irregular, up to ∼0.24 in Kepler band	(36)
ZTF J0139+5245	407197396840413696	178^{+6}_{-5}	0.000	Variable, between 15 to 25	0.29	Irregular, up to 0.6 in ZTF r	(37)
ASASSN-25bv	5332048241235589504	1030±70	0.961	Variable, between 27 to >110 (ongoing)	Unknown	Irregular, up to 0.9 in g	(38)
ZTF J185259.31+124955.2	4506139331756845568	4700^{+900}_{-700}	0.471	Variable, ∼40	0.79	0.4 in ZTF g/r and ATLAS c/o	(39)
ZTF J0347−1802	5107322396824711680	$75.6^{+0.6}_{-0.7}$	0.000	Variable, up to 70	Aperiodic	Irregular, up to ∼0.3 in ZTF r	(40)
SBSS 1232+563	1571584539980588544	172±3	0.000	Variable, up to 240	Aperiodic	Irregular, up to 0.75 achromatic	(41)
TIC 400799224	5238414793089292160	700^{+180}_{-100}	0.241	Variable	∼0.0541	Irregular	(42)
KH 15D	3326864397458223336	730±30	1.078	Variable	0.131	Variable, up to 5 in I	(43), (44)
EE Cephei	2197941958898810240	2200^{+90}_{-70}	0.289	Variable	5.6	Variable, between 0.5 to 2.0 in the optical	(45)
ZTF J0923+4236	817461778282929664	$147.7^{+1.4}_{-1.8}$	0.000	Variable	Aperiodic	Irregular, up to ∼0.5 in ZTF r	(40)
TYC 8830-410-1	6491606574121299721	$158.0^{+0.3}_{-0.4}$	0.008	Variable	Aperiodic	Irregular, up to ∼1 in V	(46)

Long and deep eclipses

Duration, period, depth relationships





Classic classification:

ε Aurigae:

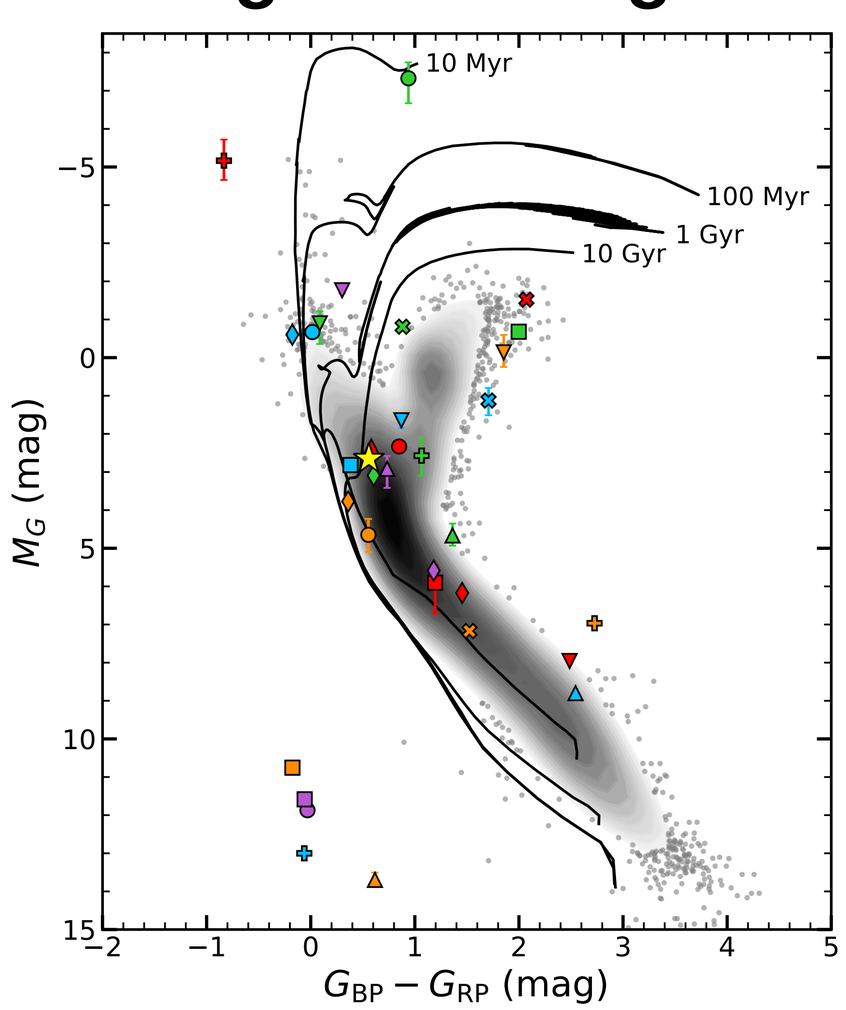
Star occulted by a stellar companion surrounded by an extended disk

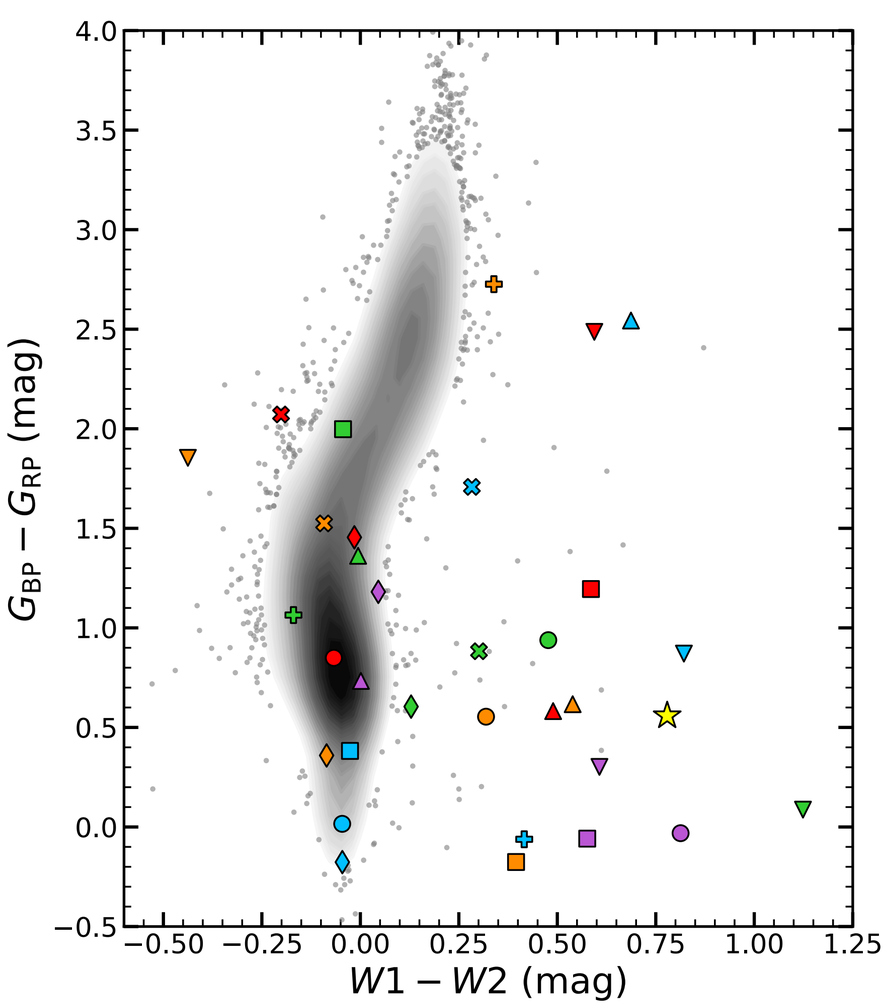
KH 15D:

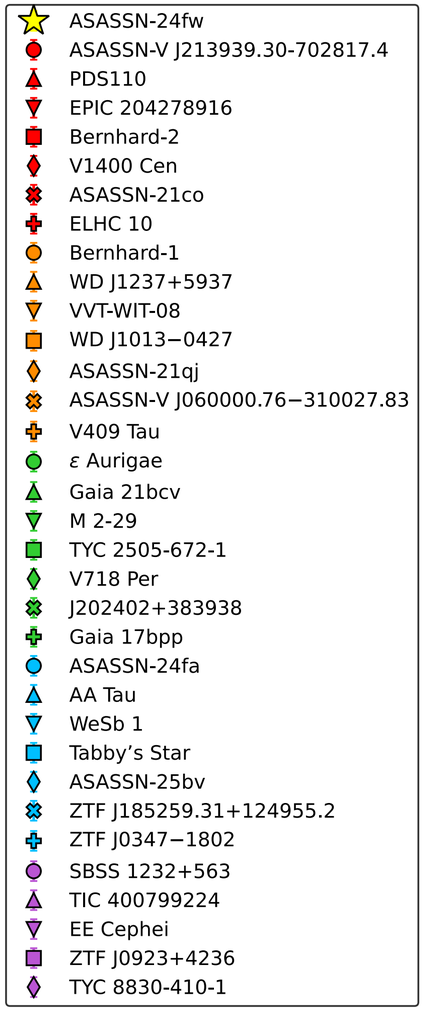
Binary system surrounded by a precessing disk

Long and deep eclipses

Color-magnitude diagram



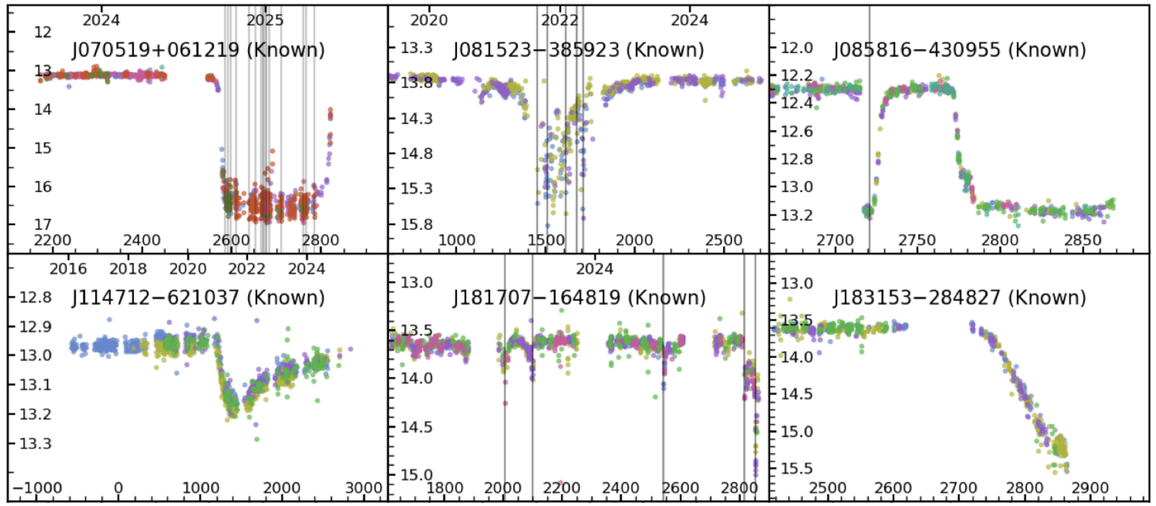


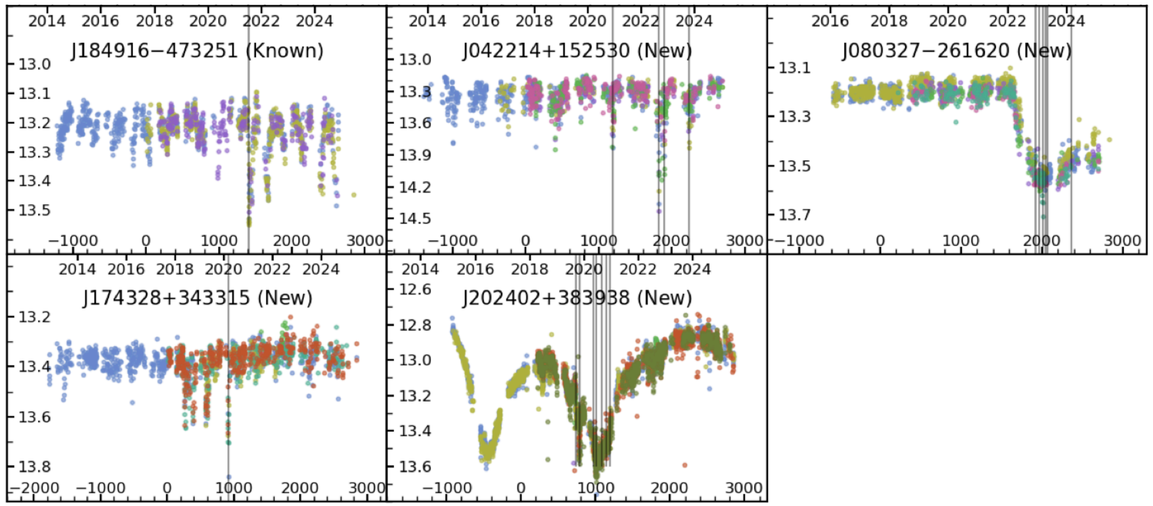


Long and deep eclipses

Searches of stellar dimmings

➡ JoHangten et al. (2025) searched systematically in ASAS-SN to find big stellar dippers





➡ Tzanidakis et al. (2025) searched for main-sequence dippers in ZTF and found 81 new dippers

More examples will help to systematically classify them and search for common features

Concluding remarks

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- ASASSN-24fw is one of the most remarkable long (8 months) and deep (4.1 mag) eclipses
- Its achromaticity and polarization indicate that the occulter is composed of big carbonaceous or water ice grains
- We propose that the occultation is driven by the precession of a dusty disk
- The population of long and deep eclipses is very broad but half of them present mid-IR excesses

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Thank you for your attention!