18455 - Time-resolved UV spectroscopy of the magnetic O star HD 54879

Cycle: 34, Proposal Category: GO

(UV Initiative)

(Availability Mode: SUPPORTED)

INVESTIGATORS

Name	*Institution*
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VISITS

Visit	*Targets used in Visit*	*Configurations used in Visit*	*Orbits Used*	*Last Orbit Planner Run*	*OP Current with Visit?*
03	(1) HD-54879	STIS/CCD STIS/FUV-MAMA	1	03-Aug-2026 17:00:52.0	yes

1 Total Orbits Used

ABSTRACT

The magnetic O-type star HD 54879 has a strong, complex magnetic field. Long-term optical spectropolarimetric monitoring has now revealed the star's extraordinarily long rotation period of 7.02 yr. Each of these characteristics are unusual among the known population of magnetic O stars. One UV spectrum of the star was previously obtained during Cycle 24, but it is now clear that the timing of this observation did not correspond with points of maximum or minimum emission, limiting our ability to constrain the wind parameters or probe the structure of HD 54879's complex magnetosphere. We propose a total of 4 new HST/STIS observations during Cycles 33-35 to obtain the first high-resolution UV spectra of the star near its positive and negative magnetic extrema and near magnetic null, which correspond to states of maximum and minimum UV emission. Since the magnetospheric structure is asymmetric, we expect the UV line profiles to vary significantly as the star rotates between these key phases. The

only way to characterize the wind structure of HD 54879's magnetosphere is through quantitative UV spectroscopy, and HST is the only instrument with which these observations can be obtained. HD 54879's uniqueness as an apparently young, slowly rotating magnetic O star with a complex magnetic field makes it a prime target to place urgently needed empirical constraints on the interplay between a complex magnetic field and stellar mass loss, as well as the field's effect on angular momentum transport and stellar evolution.

OBSERVING DESCRIPTION

This observing program continues the long-term monitoring of the complex magnetosphere of HD 54879 with two HST orbits in Cycle 33, one HST orbit in Cycle 34, and one HST orbit in Cycle 35. Each orbit will sample a unique phase of the star's ultra-long rotation period. We will use the STIS/E140M (1425 A) grating, as it provides the wavelength coverage needed to characterize the key magnetospheric diagnostics.

Our Phase I proposal relied on the flux of HD 54879 observed in the archival STIS/E140M spectra obtained as part of GO Cycle 24 program 14480 (PI: Hamann). The observing sequence in this program consisted of an ACQ with MIRROR/F25ND3 followed by a two-stage ACQ/PEAK, first in the 0.3X0.05ND aperture and then in the 0.1X0.03 "science" aperture with the G430L grating. Three ACCUM mode "science" exposures were obtained back-to-back over an interval of ~20 minutes. Our initial ETC calculations, which relied on the flux at ~1500 Angstroms measured in the third exposure and an unreddened Castelli-Kurucz flux distribution for B0 V spectral type, indicated that HD 54879 could be observed more efficiently in the 0.2X0.2 aperture without a peakup.

However, closer inspection of the archival data indicated that the flux calibration is not reliable, since the flux near 1500 Angstroms increased by nearly a factor of 2 from the first to the third exposure in the series. The observed global count rates also increased systematically, from 40722 to 47654 to 53596 counts/s for exposures od3j01010, od3j01020, and od3j01030, respectively.

For their detailed modeling of the line and continuum spectra of HD 54879 with the PoWR model atmosphere program, Shenar et al. (2017, A&A, 606, 91) renormalized the fluxes measured through the 0.1X0.03 aperture by the TD1 flux value of 3.307E-11 flam at 1565 Angstroms (which is actually quite close to the value observed in od3j01030). The parameters they derived for their best-fit model are: Teff = 30.5 pm 0.5 kK; log L = 4.45 pm 0.2 Lsun; log g = 4.0 pm 0.1 [cgs units]; Rstar = 6.1 pm 1.5 Rsun; log Mdot < -10.2 Msun/year; and E(B-V) = 0.35 pm 0.01.

Since the flux distribution for this best-fit model is significantly different from the one we used to make our Phase I estimates, we re-examined our strategy by using a model fluxes selected from the online PoWR grid (https://www.astro.physik.uni-potsdam.de/PoWR/powrgrid1.php) that closely matches the best-fit model of Shenar et al. (2017). We used the model from the GAL-OB-Vd3 grid with Teff = 30 kK, log L = 4.52 Lsun, log g = 4.0

[cgs], Rstar = 6.8 Rsun, and log Mdot = -8.30 Msun/year. All these parameters are within the uncertainties of the best-fit model of Shenar et al., though the mass-loss rate is substantially larger. This larger mass-loss rate has little effect on the fluxes in the range of STIS E140M, but - if anything - our adopted models over-predict the strength of the emission lobe of strong P Cygni profiles. The online repository of PoWR models provides synthetic spectra from 920 Angstroms to 300000 Angstroms (30 microns), which we resampled to a wavelength step of 0.5 Angstroms between 920 and 10000 Angstroms (1 micron) for use in the ETC. We used the ETC to redden the model flux distribution spectra by E(B-V) = 0.35 with the diffuse Milky Way reddening law and renormalized the flux at 1565 Angstroms to the value observed by TD1. We confirmed that the flux levels in this spectrum are very similar to those shown in Fig. 1B of Shenar et al. (e.g., 4.16E-11 flam at 1412 Angstroms).

ETC calculation STIS.sp.2024396 used this improved flux distribution for HD 54879 with the E140M grating and 0.2X0.2 aperture, but indicated that the global count-rate violated the limit for the FUV-MAMA by 6.5% (i.e., 213,111 counts/s). Consequently, we revised the observing strategy to use the 0.2X0.06 aperture. ETC calculation STIS.sp.2025056 indicates that this configuration provides ~25% margin on the global count-rate limit for the FUV-MAMA detector (147911 counts/s; see STIS.sp.2025056), while also eliminating the needfor the two-step ACQ/PEAK strategy required by the use of the 0.1X0.03 aperture in program14480. ETC predictions with the improved flux distribtuion also demonstrated the feasibility of the ACQ (with the F25ND3 aperture) and ACQ/PEAK (with the 0.2X0.05ND aperture) exposures. This observing sequence easily accommodates two E140M exposures of HD 54879 in a single orbit, each with exposure times tuned to provide the desired S/N ~ 50. The second exposure is needed to ensure the desired S/N, especially in case of loss of signal in a narrow aperture due to guiding jitter.

Visit

Proposal 18455, Visit 03, implementation — Mon Aug 03 21:00:52 GMT 2026

Diagnostic Status: No Diagnostics

Scientific Instruments: STIS/CCD, STIS/FUV-MAMA

Special Requirements: BETWEEN 01-NOV-2026:00:00:00 AND 31-OCT-2027:00:00:00

Fixed Targets

#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous
(1)	HD-54879	RA: 07 10 8.1488 (107.5339533d) Dec: -11 48 9.84 (-11.80273d) Equinox: J2000	Proper Motion RA: -2.808 mas/yr Proper Motion Dec: 1.27 mas/yr Parallax: 7.99E-4" Epoch of Position: 2000	V=7.65 3.3E-11 flam at 1565 Angstroms	Reference Frame: ICRS

Comments: This object was generated by the targetselector and retrieved from the SIMBAD database.

SIMBAD listed proper motion for this target. When retrieving targets with PM from SIMBAD, APT requests the coordinates be calculated with an epoch of the year 2000. Do not modify this epoch. Always review coordinates using the Target Confirmation tool, which graphically displays the PM.
Category=STAR
Description=[CIRCUMSTELLAR MATTER, MAIN SEQUENCE O, WIND]
Extended=NO

Exposures

#	Label (ETC Run)	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
1	(STIS.ta.2025086)	(1) HD-54879	STIS/CCD, ACQ, F25ND3	MIRROR				0.2 Secs (0.2 Secs) *[==>]*	***[1]***
2	(STIS.ta.2025088)	(1) HD-54879	STIS/CCD, ACQ/PEAK, 0.2X0.05ND	MIRROR				0.2 Secs (0.2 Secs) *[==>]*	***[1]***
3	(STIS.sp.2025090)	(1) HD-54879	STIS/FUV-MAMA, ACCUM, 0.2X0.06	E140M 1425 A				700 Secs (727 Secs) *[==>727.0 Secs]*	***[1]***
4	(STIS.sp.2025090)	(1) HD-54879	STIS/FUV-MAMA, ACCUM, 0.2X0.06	E140M 1425 A				700 Secs (727 Secs) *[==>727.0 Secs]*	***[1]***

Exposure 1 — *Comments: The ETC issues a warning that the exposure time required to reach the recommended S/N=40 is less than the minimum exposure time for the CCD (0.1 s). The exposure time has arbitrarily doubled to 0.2 s to ensure a good ACQ.*

Exposure 2 — *Comments: The ETC issues a warning that the exposure time required to reach the recommended S/N=40 is less than the minimum exposure time for the CCD (0.1 s). The exposure time has arbitrarily doubled to 0.2 s to ensure a good ACQ.*

Exposure 3 — *Comments: The ETC warns that the total count-rate per image exceeds the limit for irregularly-variable sources, which is not applicable to HD-54879. The ETC also warns that buffer time is less than 99 s, but this is not relevant to ACCUM mode. The estimated time to achieve S/N = 50 at 1500 Angstroms has been rounded up from 590 s to 700 s.*

Exposure 4 — *Comments: The ETC warns that the total count-rate per image exceeds the limit for irregularly-variable sources, which is not applicable to HD-54879. The ETC also warns that buffer time is less than 99 s, but this is not relevant to ACCUM mode. The estimated time to achieve S/N = 50 at 1500 Angstroms has been rounded up from 590 s to 700 s.*

Proposal 18455 - Visit 03 - Time-resolved UV spectroscopy of the magnetic O star HD 54879