16206 - Mass determination of an extreme halo M subdwarf through astrometric and photometric microlensing

Cycle: 28, Proposal Category: GO

(Availability Mode: SUPPORTED)

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VISITS

Visit	*Targets used in Visit*	*Configurations used in Visit*	*Orbits Used*	*Last Orbit Planner Run*	*OP Current with Visit?*
01	(2) J1305-SOURCE	WFC3/UVIS	1	09-Aug-2021 12:00:19.0	yes

1 Total Orbits Used

ABSTRACT

We propose to measure the mass of the isolated M subdwarf 2MASS J13055171-7218081 (hereafter J1305), using both photometric and astrometric microlensing techniques. Searches of the recent Gaia DR2 have led to predictions of over 100 close passages of nearby stars in front of background sources that will occur in the next 20 years. Among these, J1305 is the closest of all, predicted to have a remarkably small impact parameter of ~5.8 mas, occuring in 2019 November.

As J1305 passes in front, it will cause a relativistic deflection of the background star by ~0.9 milliarcsec, and a photometric brightening by ~5.5%. The deflections and the amplifications, measured with HST's WFC3, will provide the first opportunity to derive a lens mass through BOTH photometric and astrometric microlensing methods. The estimated accuracy of our mass measurement is ~4%.

J1305 is of special interest as an extreme halo M subdwarf, having a transverse velocity of 236 km/s, and lying 3 magnitudes below the Population I main sequence. Spectroscopic observations show it to be an M3 dwarf with a very low metallicity of [Fe/H] = -1.8. Its estimated mass is ~0.11 Msun, but this is exquisitely sensitive to luminosity, effective temperature, and metallicity.

To date, there are only a small number of mass measurements, based on binary stars, for metal-deficient M dwarfs, and none at all for masses less than 0.17 Msun or for [Fe/H] < -0.9. Our program will provide the first direct, model-independent mass determination for an extremely metal-deficient M dwarf, and a critical test of theoretical models for metal poor, low-mass stars.

OBSERVING DESCRIPTION

We will image the field at 10 epochs as shown in Fig. 4, to monitor the brightening of the source during the photometric event; and to measure its astrometric position to detect the relativistic deflection, and to precisely determine the trajectory of the lens with respect to the source.

At all the 10 epochs, we will obtain dithered images using the WFC3/UVIS F555W (V - band) filter. (We use direct imaging, since the background source is too faint for us to use the technique of spatial scanning introduced by Riess et al. 2014.) F555W is the bluest filter for which the PSF is well characterized for precision astrometry and photometry. Anderson private communications); a blue filter is desirable because the lens star is brighter and redder than the source. (The magnitude difference in the Gaia blue filter is only 0.6 mag, vs. 1.3 mag in the red filter.) We will use a 2k x 2k subarray to ensure that there are enough reference stars within the field, yet interruptions for buffer dumps will be unnecessary. At one epoch we will also obtain a few frames in F814W (I-band) in order to estimate the spectral types and distances of the reference stars, some of which are too faint for Gaia.

Our strategy is to obtain 8 epochs during the astrometric event, which can also be used to measure photometric amplifications at 6 epochs, and the baseline at 2 epochs (see Fig. 4). Two additional epochs at late times provide the proper motions of the source and reference stars in the HST astrometric frame, and are taken 1 year apart at identical parallax factors. They will provide an accurate knowledge of the trajectory of the lens/source in the HST astrometric frame, which is necessary for both the photometric and the astrometric techniques. The additional observations at late times will also provide a check on any possible intrinsic variability of lens or source at millimag level (expected to be minimal for a very old dM star and the background K dwarf). These considerations make it necessary to observe the event over two HST Cycles.

Scheduling: The desired epochs of observations close to the peak amplification and deflection are indicated in Figure 4 of our phase-I proposal, and require scheduling tolerances of a few days. The observations must begin as soon as possible after the start of Cycle 27. Away from the peak, the tolerances are considerably relaxed.

Orientation: It will be necessary to use spacecraft orientations that will avoid diffraction spikes from the lens affecting the astrometry of the background star. However, the range of angles to avoid is small, and easily schedulable.

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Visit

Proposal 16206, Visit 01, implementation — Mon Aug 09 16:00:20 GMT 2021

Diagnostic Status: Warning

Scientific Instruments: WFC3/UVIS

Special Requirements: (none)

Diagnostics

(Exposure 1 (Visit 01)) Warning (Form): FLASH level may be too high for this exposure or a long subexposure. See extended explanation in the diagnostic browser
(Exposure 2 (Visit 01)) Warning (Form): FLASH level may be too high for this exposure or a long subexposure. See extended explanation in the diagnostic browser
(Exposure 3 (Visit 01)) Warning (Form): FLASH level may be too high for this exposure or a long subexposure. See extended explanation in the diagnostic browser
(Exposure 4 (Visit 01)) Warning (Form): FLASH level may be too high for this exposure or a long subexposure. See extended explanation in the diagnostic browser
(Exposure 5 (Visit 01)) Warning (Form): FLASH level may be too high for this exposure or a long subexposure. See extended explanation in the diagnostic browser
(Exposure 6 (Visit 01)) Warning (Form): FLASH level may be too high for this exposure or a long subexposure. See extended explanation in the diagnostic browser
(Exposure 7 (Visit 01)) Warning (Form): FLASH level may be too high for this exposure or a long subexposure. See extended explanation in the diagnostic browser
(Exposure 8 (Visit 01)) Warning (Form): FLASH level may be too high for this exposure or a long subexposure. See extended explanation in the diagnostic browser
(Exposure 9 (Visit 01)) Warning (Form): FLASH level may be too high for this exposure or a long subexposure. See extended explanation in the diagnostic browser
(Exposure 10 (Visit 01)) Warning (Form): FLASH level may be too high for this exposure or a long subexposure. See extended explanation in the diagnostic browser

Fixed Targets

#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous
(2)	J1305-SOURCE	RA: 13 05 50.1680 (196.4590333d) Dec: -72 18 2.26 (-72.30063d) Equinox: J2000		V=18.15	Reference Frame: ICRS

Comments:
Category=EXT-STAR
Description=[K V-IV]

Exposures

#	Label	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
1		(2) J1305-SOURCE	WFC3/UVIS, ACCUM, UVIS2-2K2C-SUB	F555W	CR-SPLIT=NO; FLASH=19	POS TARG 10.4,9		75 Secs (75 Secs) *[==>]*	***[1]***
2		(2) J1305-SOURCE	WFC3/UVIS, ACCUM, UVIS2-2K2C-SUB	F555W	CR-SPLIT=NO; FLASH=19	POS TARG 15.34,9		75 Secs (75 Secs) *[==>]*	***[1]***
3		(2) J1305-SOURCE	WFC3/UVIS, ACCUM, UVIS2-2K2C-SUB	F555W	CR-SPLIT=NO; FLASH=19	POS TARG 14.18,12.18		75 Secs (75 Secs) *[==>]*	***[1]***
4		(2) J1305-SOURCE	WFC3/UVIS, ACCUM, UVIS2-2K2C-SUB	F555W	CR-SPLIT=NO; FLASH=19	POS TARG 11.25,13.86		75 Secs (75 Secs) *[==>]*	***[1]***
5		(2) J1305-SOURCE	WFC3/UVIS, ACCUM, UVIS2-2K2C-SUB	F555W	CR-SPLIT=NO; FLASH=19	POS TARG 7.92,13.27		75 Secs (75 Secs) *[==>]*	***[1]***
6		(2) J1305-SOURCE	WFC3/UVIS, ACCUM, UVIS2-2K2C-SUB	F555W	CR-SPLIT=NO; FLASH=19	POS TARG 5.75,10.67		75 Secs (75 Secs) *[==>]*	***[1]***
7		(2) J1305-SOURCE	WFC3/UVIS, ACCUM, UVIS2-2K2C-SUB	F555W	CR-SPLIT=NO; FLASH=19	POS TARG 5.77,7.29		75 Secs (75 Secs) *[==>]*	***[1]***
8		(2) J1305-SOURCE	WFC3/UVIS, ACCUM, UVIS2-2K2C-SUB	F555W	CR-SPLIT=NO; FLASH=19	POS TARG 7.96,4.71		75 Secs (75 Secs) *[==>]*	***[1]***
9		(2) J1305-SOURCE	WFC3/UVIS, ACCUM, UVIS2-2K2C-SUB	F555W	CR-SPLIT=NO; FLASH=19	POS TARG 11.29,4.14		75 Secs (75 Secs) *[==>]*	***[1]***
10		(2) J1305-SOURCE	WFC3/UVIS, ACCUM, UVIS2-2K2C-SUB	F555W	CR-SPLIT=NO; FLASH=19	POS TARG 14.21,5.86		75 Secs (75 Secs) *[==>]*	***[1]***

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Orbit Structure