

Spectral Energy Distribution Analyzer (SEDA) for Forward Modeling of Ultracool Objects



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Stanimir Metchev (UWO)

Sherelyn Alejandro Merchan (CUNY)

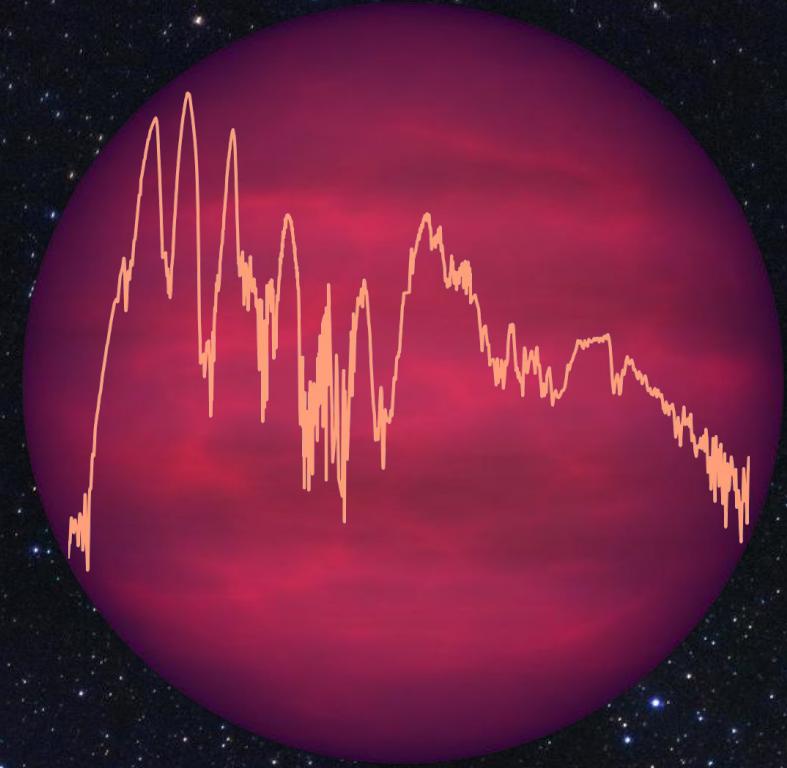
Austin Rothermich (CUNY)

Daniella Bardalez Gagliuffi (Amherst College)

Niall Whiteford (AMNH)

SEDA Overview

Open-source Python package for forward modeling analysis of brown dwarfs, directly imaged exoplanets, and low-mass stars.

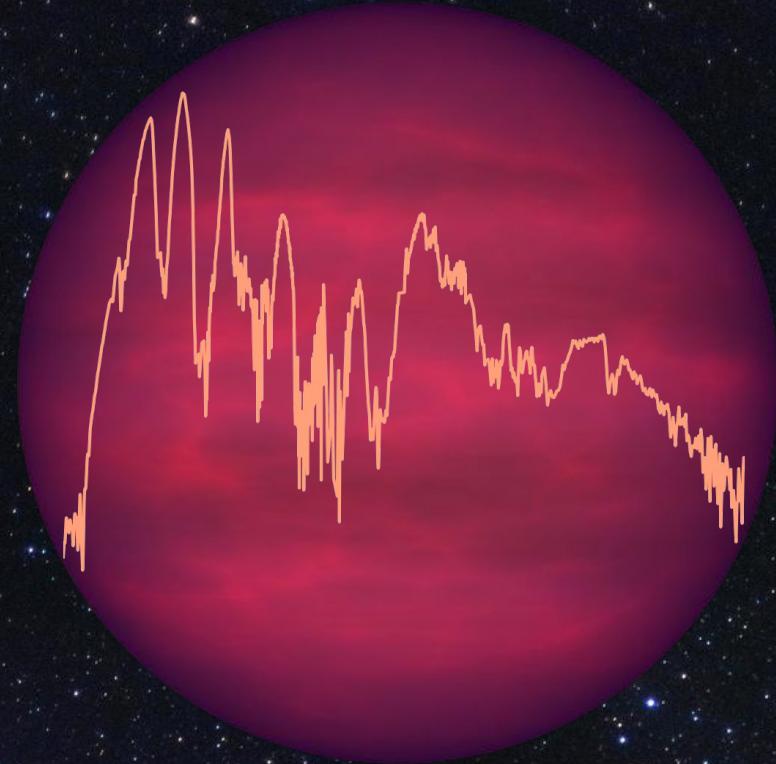


SEDA Overview

Open-source Python package for forward modeling analysis of brown dwarfs, directly imaged exoplanets, and low-mass stars.

Compares spectra and/or photometry to atmospheric models by using a Bayesian framework to sample posteriors.

Dynesty (Speagle 2020) for dynamic nested sampling.



SEDA Overview

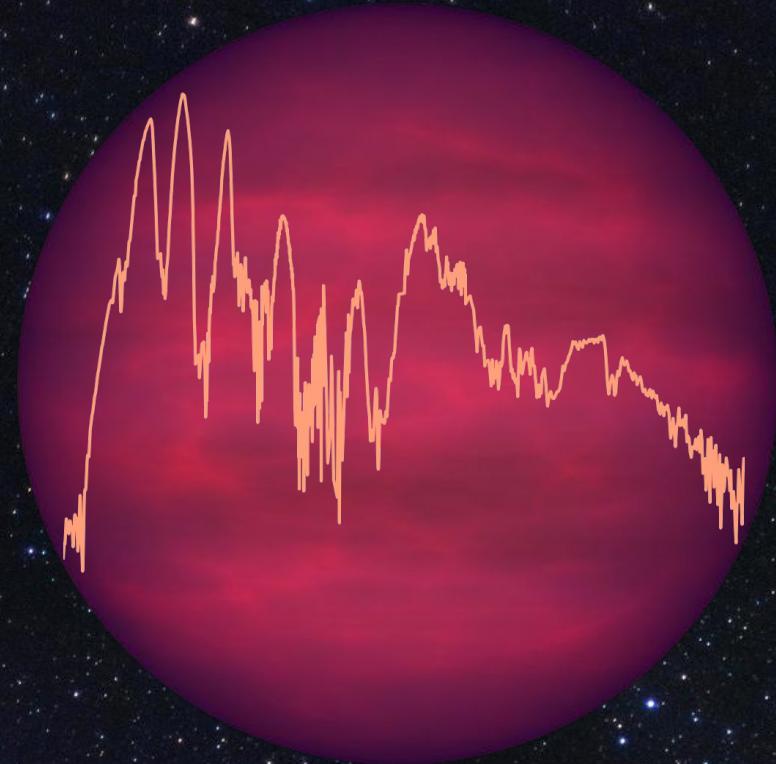
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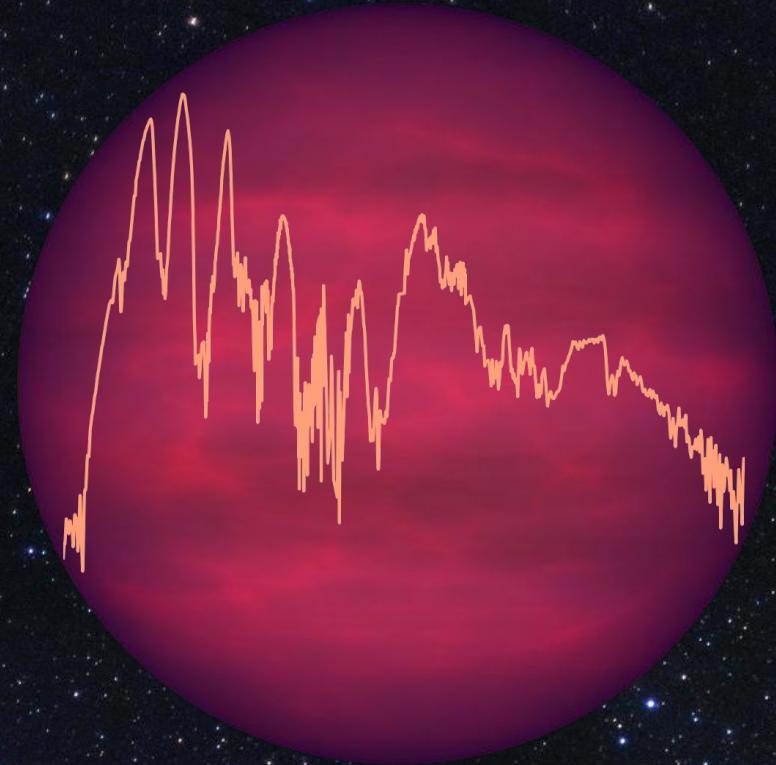
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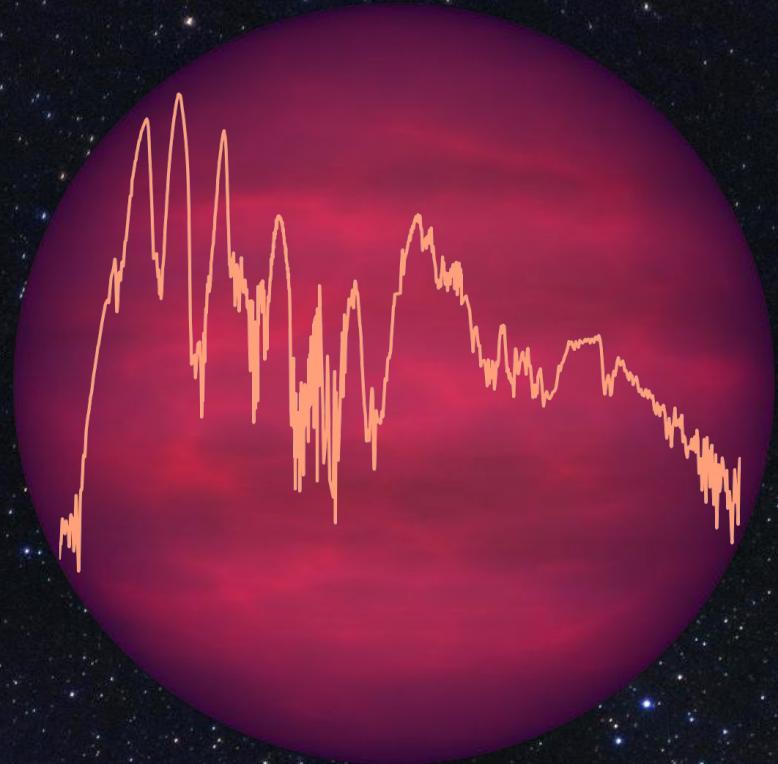
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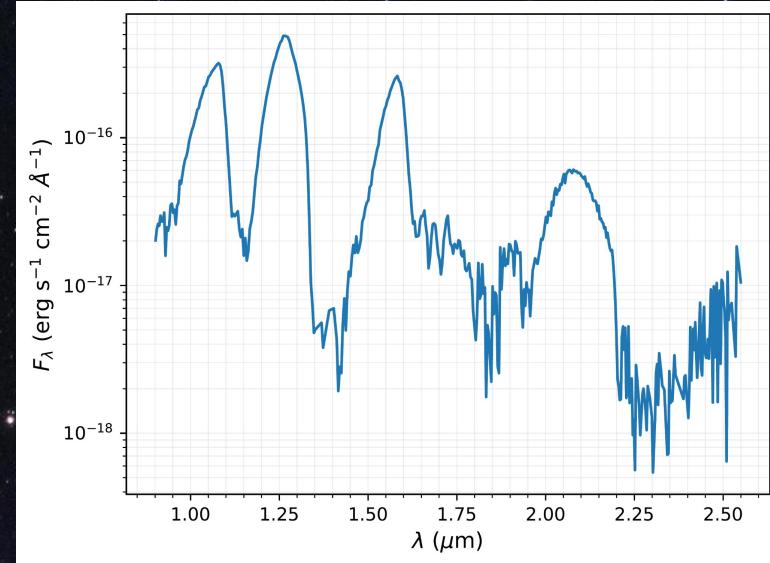
Several tools useful for the analysis of SEDs.



SEDA Workflow

Load input spectrum

IRTF/SpeX spectrum for the T8 (~750 K)
brown dwarf J0415 (Burgasser+2004):



SEDA Workflow

Load input spectrum



Download and input atmospheric models

Available atmospheric models:

- Sonora Elf Owl models (Mukherjee et al. 2024)
- Sonora Diamondback (Morley et al. 2024)
- Lacy & Burrows (2023)
- Sonora Cholla (Karalidi et al. 2021)
- Sonora Bobcat (Marley et al. 2021)
- ATMO 2020 (Phillips et al. 2020)
- BT-Settl (Allard et al. 2012)
- Saumon & Marley (2008)

SEDA Workflow

Load input spectrum



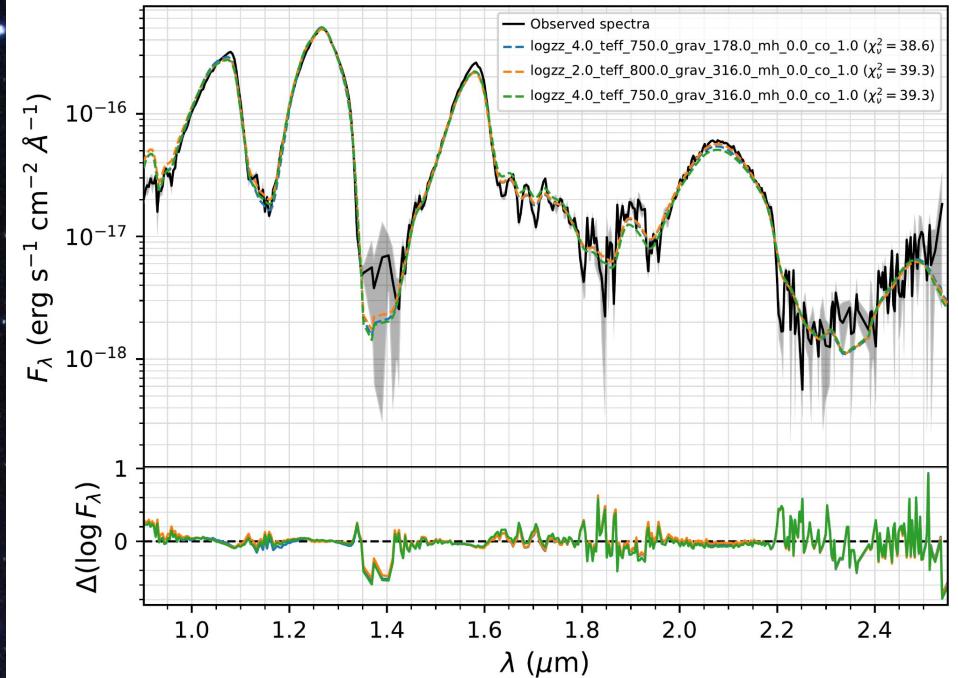
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Chi-square fit

Best three model fits

Sonora Elf Owl Atmospheric Models



SEDA Workflow

Load input spectrum

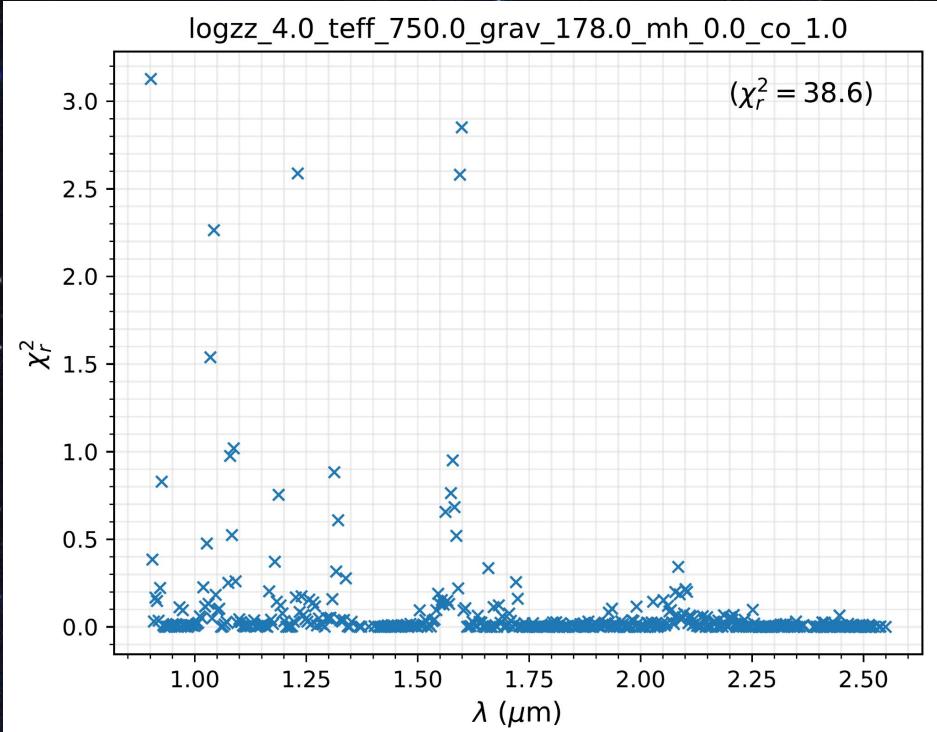


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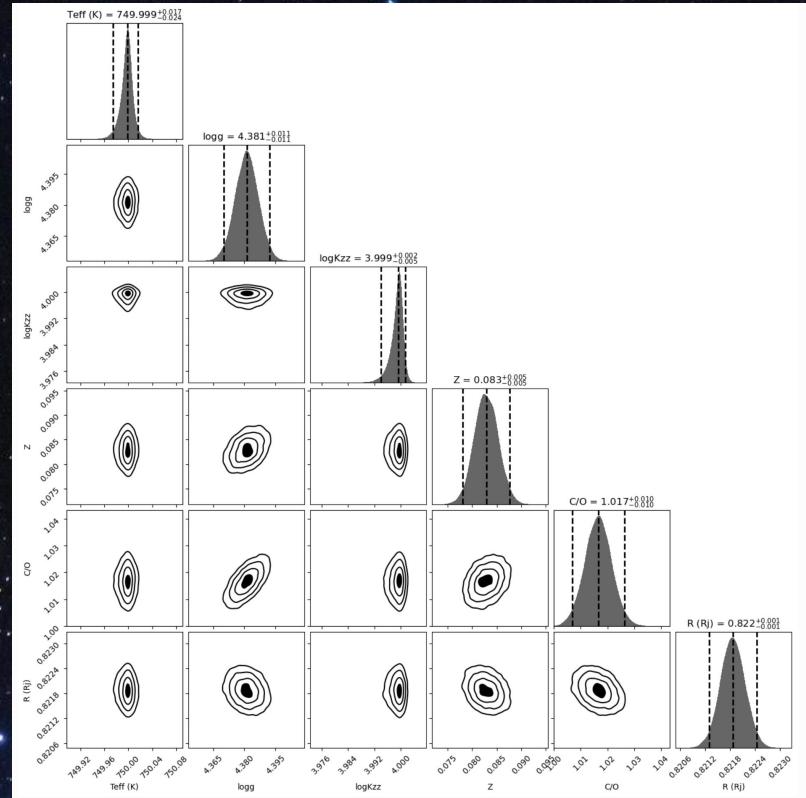
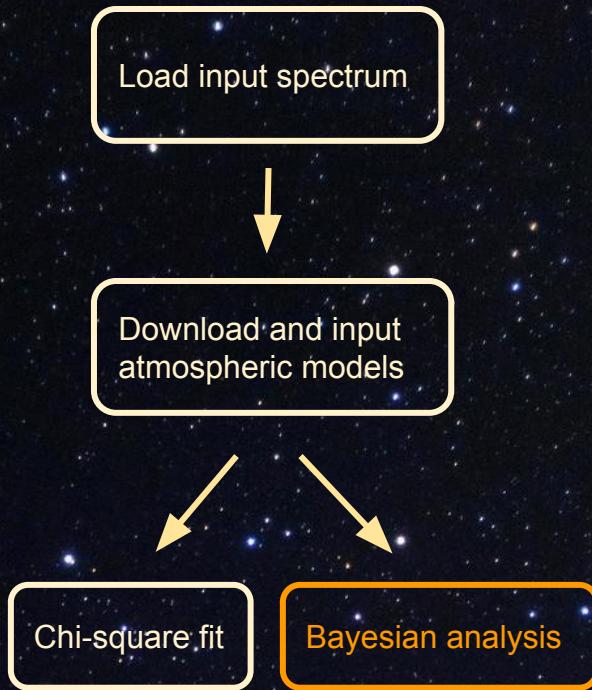
Chi-square fit

Reduced chi-square as a function of wavelength

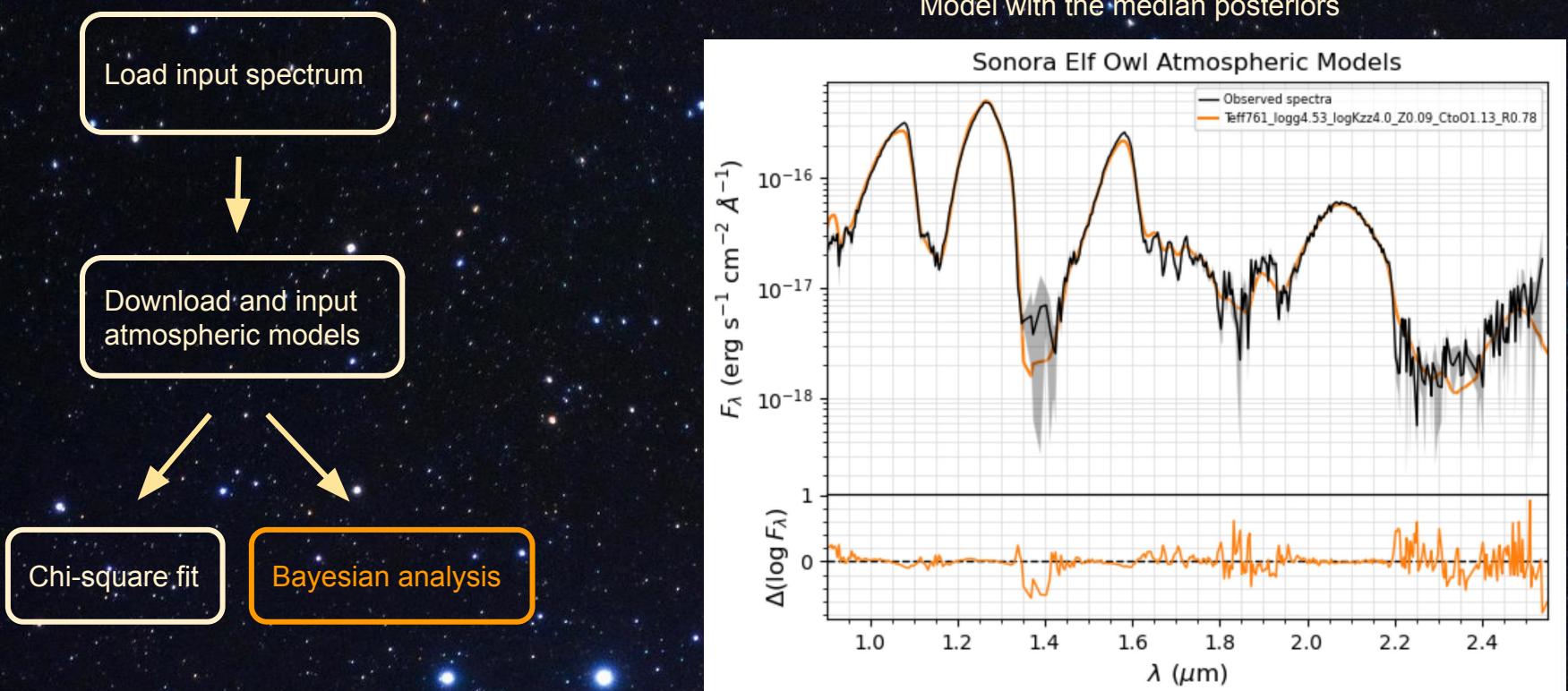


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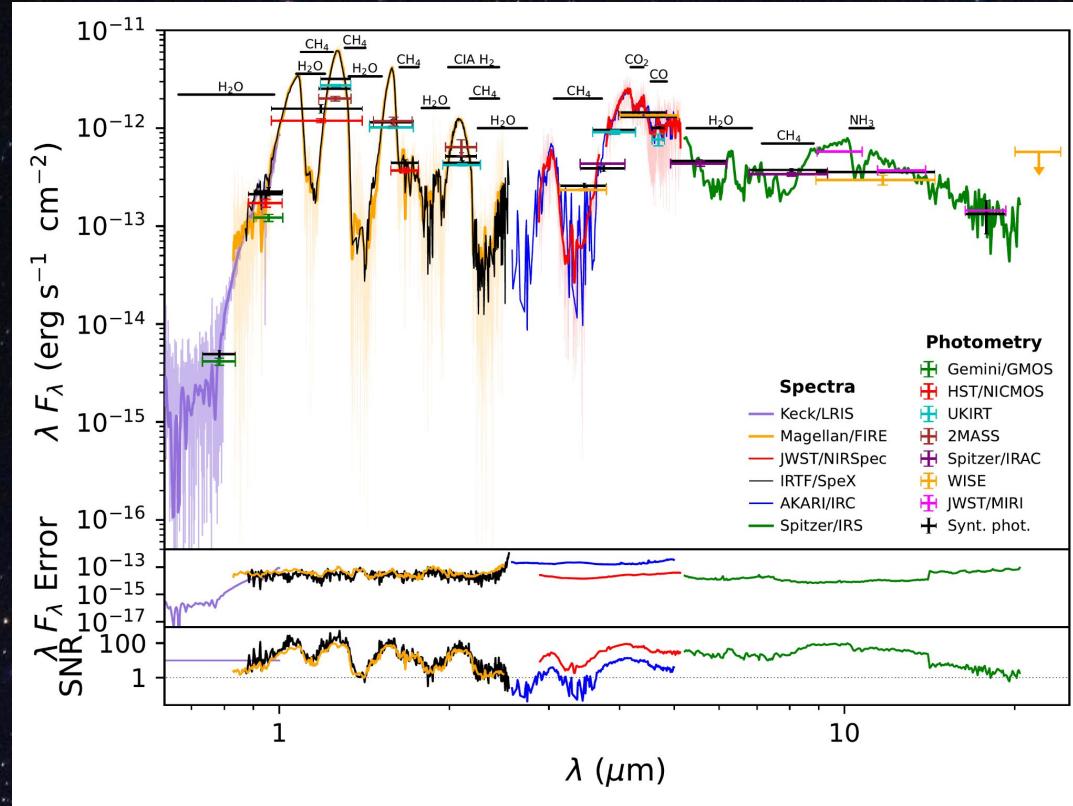
Corner plot with the posteriors



SEDA Workflow

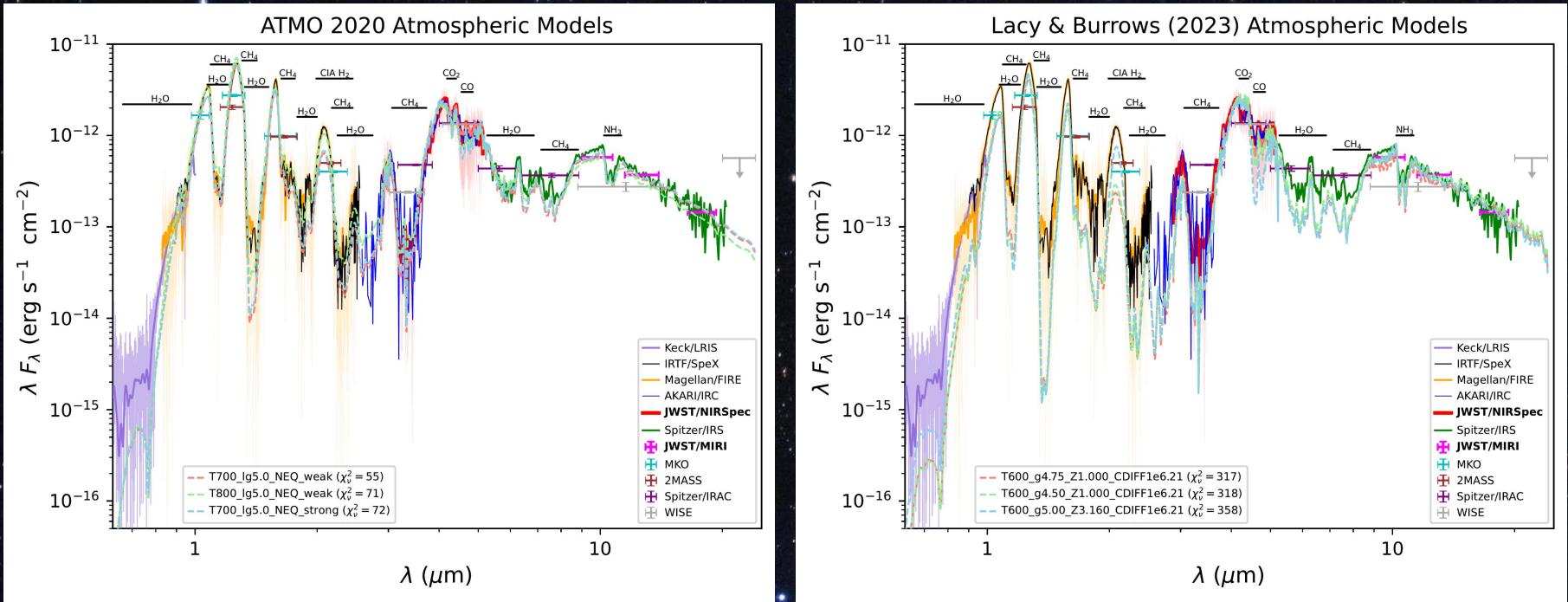


Modeling a Full SED



Alejandro Merchan et al. (2024, in prep.)

Modeling a Full SED



Suárez et al. (2025, in prep.)

Principal SEDA Tools

- Synthetic photometry for any SVO filters

Filter Profile Service
Carlos Rodrigo

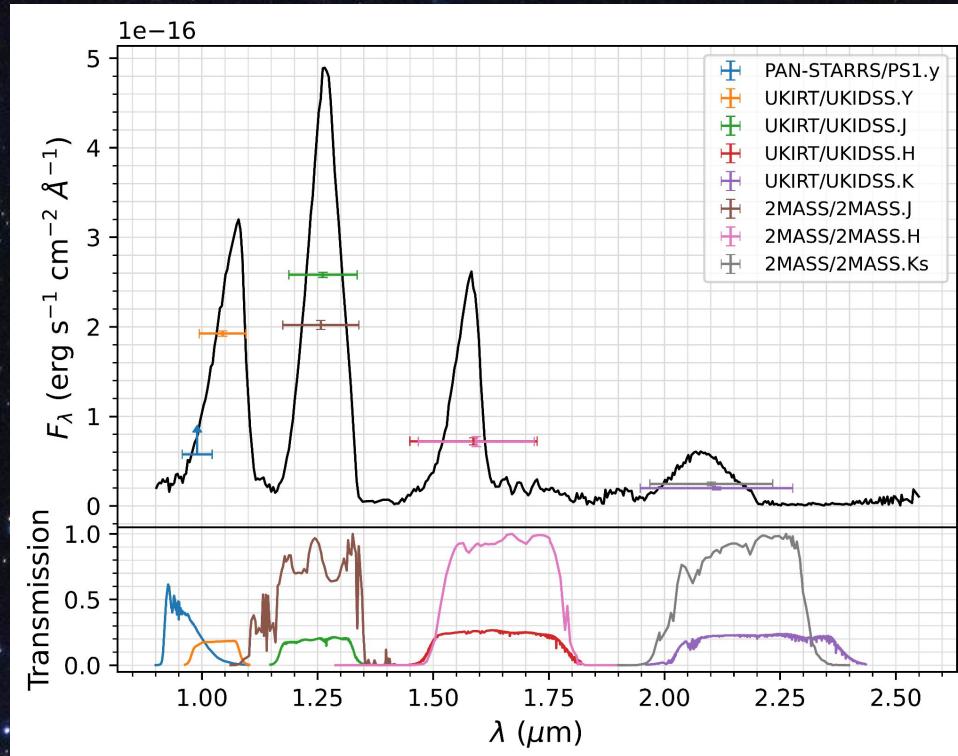
A repository of filter information for the VO.

VO Service Browse Search News Help-Desk

Search text ~ Search (?)

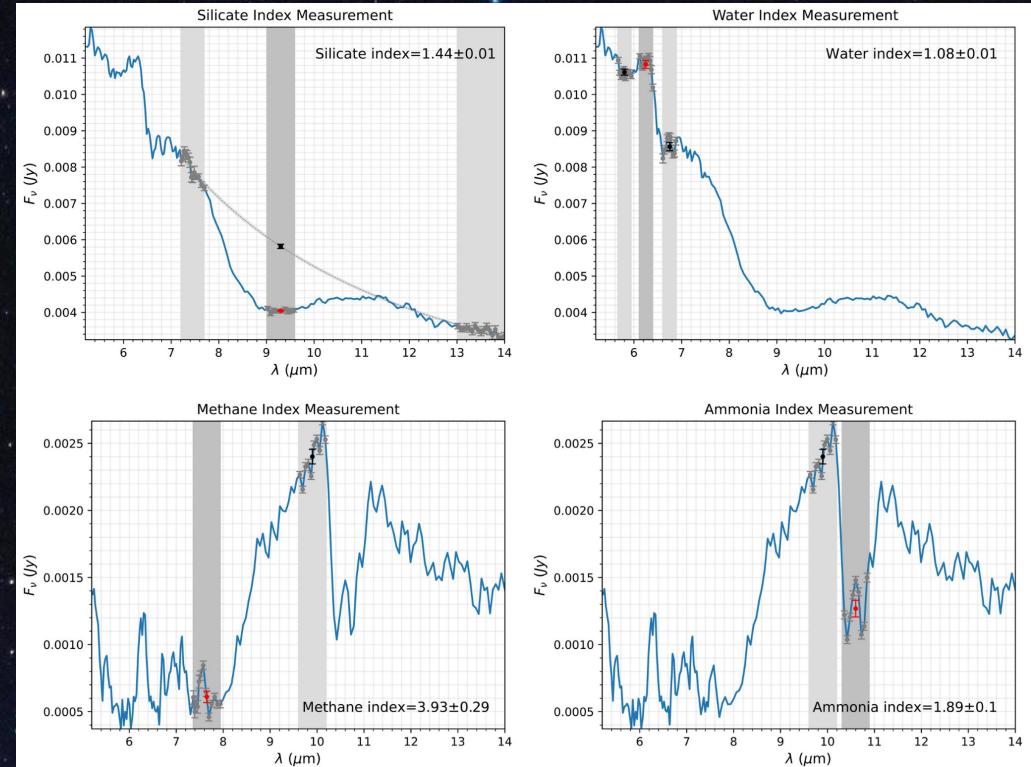
Astronomy (7905) Planetary science (616) Earth Obs. (2452)

2MASS	AAO	ADEOS	AKARI	Akatsuki	AlSat1	APEX	APD	Aqua	ARCHEOPS	ARGO	Astrosat	Beijing1	Bepi-Colombo	BICEP
BLAST	BOK	BOOMERANG	CAHA	Cameras	Cassini	CASTOR	CFHT	CHEOPS	Clementine	CHD-SAI	COBE	COMS	Contour	Corot
COSMOSMAS	CSST	CSTAR	CTIO	Dawn	DeepImpact	DENIS	DOT	DSCOVER	Envisat	ERBS	EROS	ERS	ESO	Euclid
Exofars	Fengyun	Flock	FLWO	GAIA	GALEX	Galileo	GCOM-C	GCPD	Gemini	Generic	Geneva	GeoEye	Giotto	GOES
GOTO	GTC	Hayabusa2	HCT	Herschel	Hinawari	Hipparcos	HST	JACBA	IKONOS	ING	INSAT	InSight	INT	Integral
IRAM	IRAS	IRS	IRSF	IRTF	ISO	IUE	JCMT	JPPS	JWST	Keck	Kepler	KOMPSTAT	KPNO	Landsat
LasCumbres	LaSilla	LBT	LCO	LIC	Liverpool	LMT	LRO	LSST	LYRA	Mariner10	Marinor10	MAXIMA	MCD	MER
Mercator	Messenger	Meteosat	METOP	MEX	Mic	MKO	MHT	MOA	MOM	MOST	MRO	MSX	MT	NAOC
NEAR	NewHorizons	NigeriaSat1	NIMBUS	NIIRT	NOAA	NOAO	NOT	OAF	OAO	OAN-SPM	OAO	Odyssey	OHP	OLINPO
OSIRIS-REX	DSN	OVRO	P200	Palomar	PAN-STARRS	Paranal	Parrot	Pathfinder	PLANCK	Pléiades	PRIRODA	QuickBird	QUIET	QUIJOTE
ReconEye	Roman	Rosetta	SALT	SAO	Scorpio	SeaStar	Selene	Sentinel	SFOCAT	SkyMapper	SLOAN	SMARTI	SOFIA	
SOHO	SolarOrbiter	Special	SPECULOOS	SPIDER	Spitzer	SPOT	SPITZ	SSOT	Stardust	STELLA	Subaru	Swift	TAUVEX	TCS
T01	Terra	TESS	TIROS-N	TIRO	THO	THO	TINT	TopHat	TMRH	TYCHO	UK-DIC	UKIRT	VATT	VenusExpress
Viking	Voyager	WASP	WFIRST	WHT	WISE	WMAP	WorldView	XMM	Ziruan					



Principal SEDA Tools

- Synthetic photometry
- Measure the depth of spectral features

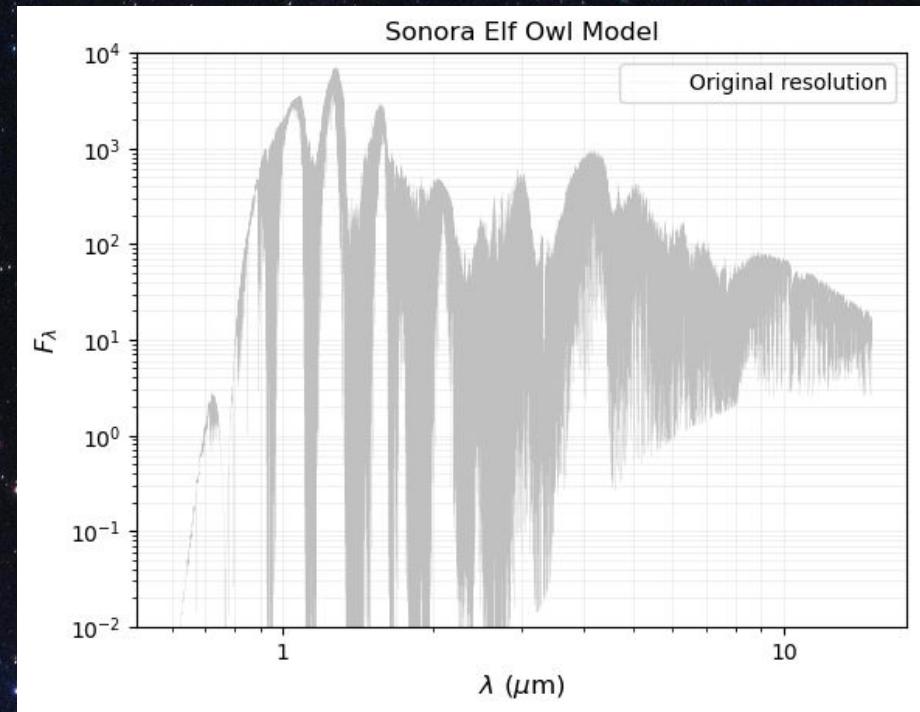


Principal SEDA Tools

- Synthetic photometry
- Measure the depth of spectral features
- Generate model spectra with parameters within the grid coverage

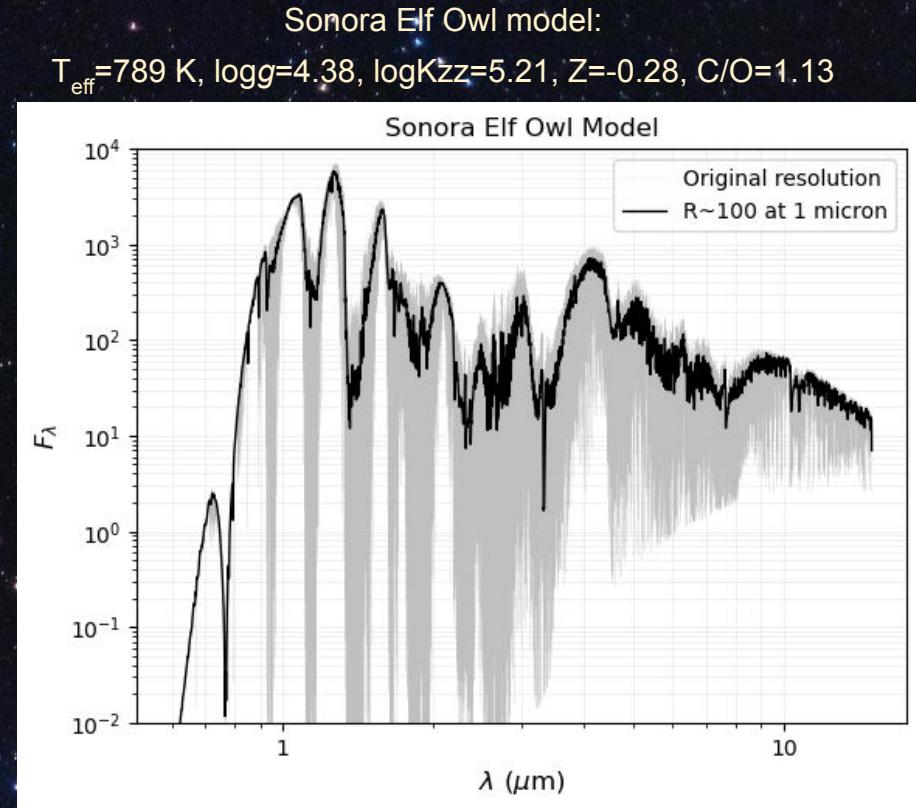
Sonora Elf Owl model:

$T_{\text{eff}} = 789 \text{ K}$, $\log g = 4.38$, $\log K_{\text{zz}} = 5.21$, $Z = -0.28$, $\text{C/O} = 1.13$



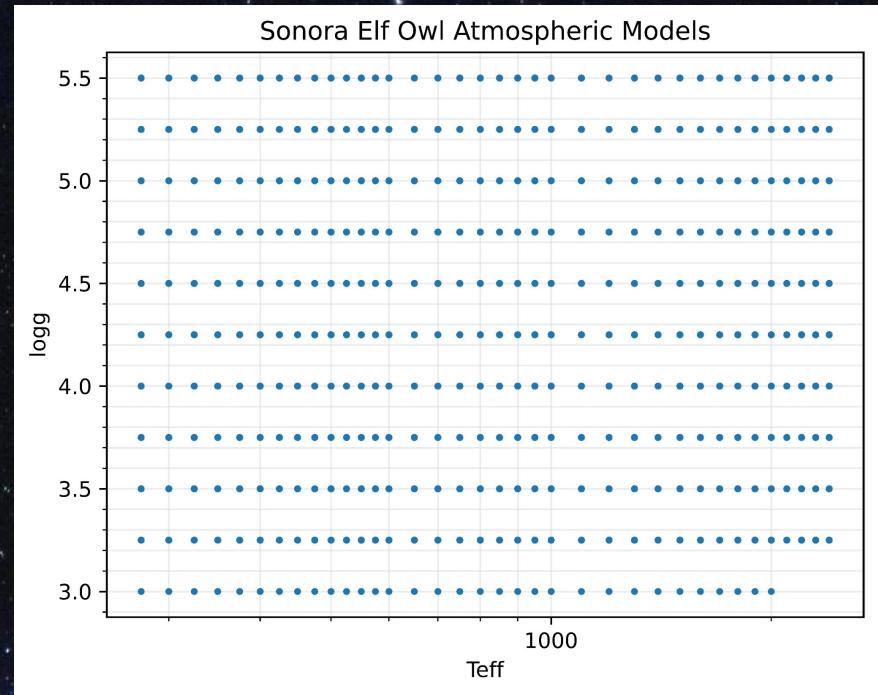
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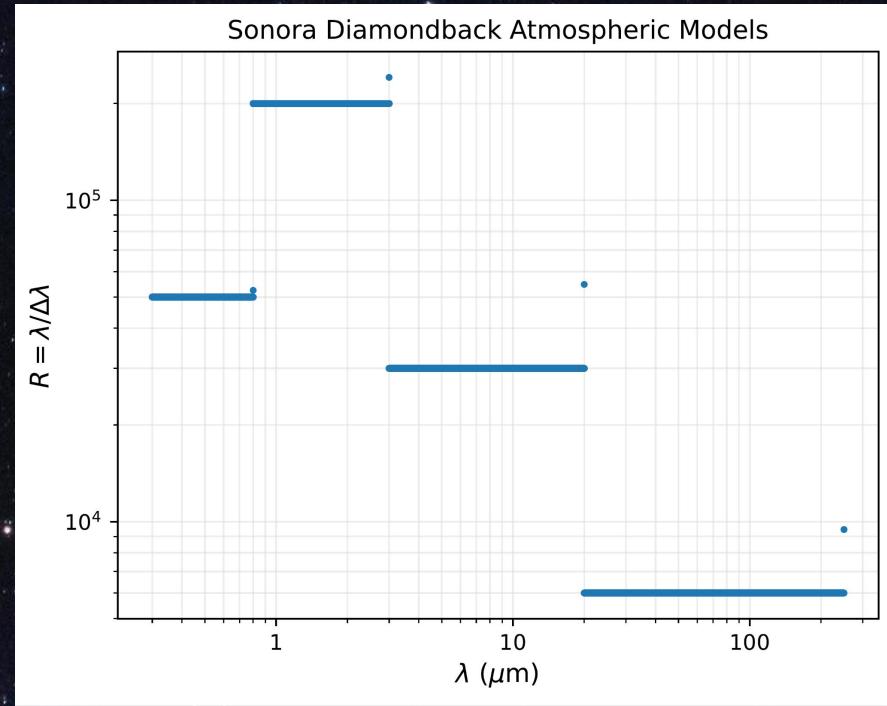
Principal SEDA Tools

- Synthetic photometry
- Measure the depth of spectral features
- Generate model spectra with parameters within the grid coverage
- Convolve spectra to a desired resolution
- Inspect model parameters coverage and resolution



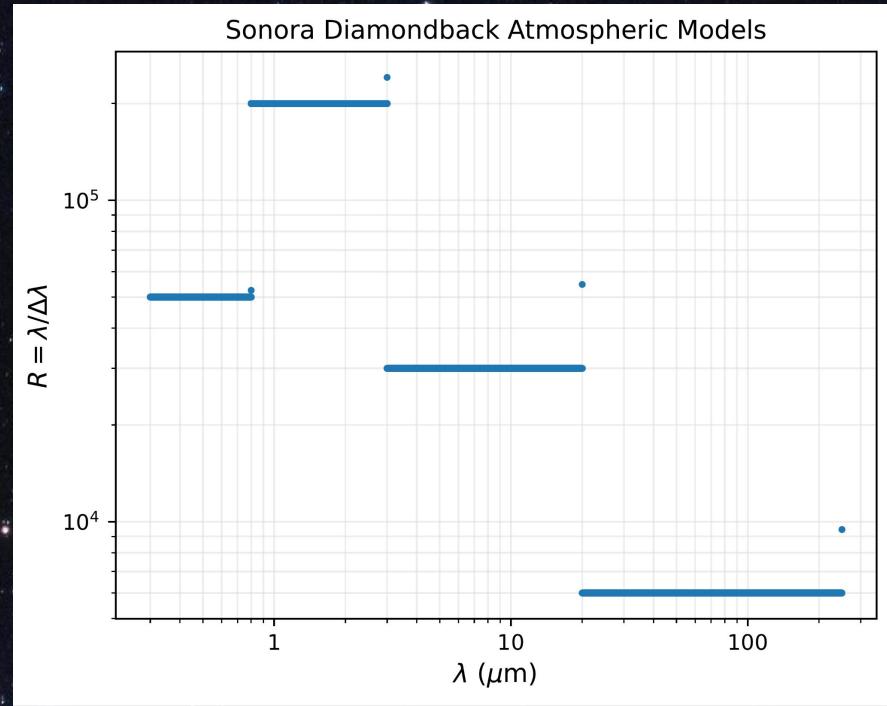
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Principal SEDA Tools

- Synthetic photometry
- Measure the depth of spectral features
- Generate model spectra with parameters within the grid coverage
- Convolve spectra to a desired resolution
- Inspect model parameters coverage and resolution
- Convert fluxes into magnitudes and vice versa



Takeaway

Check out the SEDA package to model and inspect SEDs of ultracool objects.



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Check out the SEDA python package to model and inspect SEDs of ultracool objects.



SEDA

Search docs

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- Installation
- Overview
- Tutorials
- Github
- API
- About SEDA

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Check out the content below for further information on how to install and use SEDA.

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- Tutorials
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 - Chi-square minimization for a single observed spectra
 - Chi-square minimization for multiple observed spectra
 - Nested sampling for a single observed spectrum
 - Nested sampling for multiple spectra of the same object
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 - Chi-square Fit
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 - Plots
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 - Attribution
 - Contributing
 - Questions and feedback
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 - FAQs

SEDA: Spectral Energy Distribution Analyzer for Ultracool Objects

B D N Y C

Genaro Suárez (gsuarez@amnh.org)

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Thanks for listening!

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