The Star-Planet Activity Research CubeSat (SPARCS)
A Mission to Understand the Radiation Impact of Stars in Exoplanets

David Ardila
SPARCS Instrument Scientist
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SPARCS

• Determine UV variability of low-mass stars at short (minutes) and long (months) timescales

• 6U CubeSat

• 9 cm telescope, ultraviolet camera: FUV [153-171 nm] & NUV [258-308 nm]

• ACS jitter: 6” in 10 min; 238 K passive radiative cooling

• 1 year of dedicated monitoring of 12 low-mass stars from a sun-sync orbit 6pm

• Photometric precision: 10%

• Funded NASA APRA program: Launch 2021
Principal Investigator
Evgenya Shkolnik (ASU)

Science
David Ardila (JPL)
Travis Barman (UA)
Varoujan Gorjian (JPL)
Joe Llama (Lowell)
Victoria Meadows (UW)
Evgenya Shkolnik (ASU)
Mark Swain (JPL)
Robert Zellem (JPL)

Systems Engineer
Daniel Jacobs (ASU)

Instrument Scientist
David Ardila (JPL)

CubeSat Telescope and I&T
Paul Scowen (ASU)
Matt Beasley (SWRI)
Connie Spittler (ASU)

Camera/Detector
Shouleh Nikzad (JPL)
April Jewell (JPL)

Operations/Software
Judd Bowman (ASU)
Unique challenges for Astrophysics CubeSats

- **Astrophysics is signal-starved**: The larger the aperture the better.
- **Exposures are long**: Jitter and thermoelastic changes will spread the light and reduce the sensitivity.
- **Missions are long**: Targets are distributed all over the sky. Parts need to survive at least a year, operating costs are larger.
- **Doing the same will not sell**: Exploring a new region of parameter space is required.
- **CubeSats and SmallSats need to find unique niches that cannot be filled with larger missions.**
CubeSat (and SmallSat) work takes place in an existing context
SPARCS’ science mission: Study UV environment of exoplanets around M dwarf stars*

They are abundant (70% of all) and small

20 HZ* planets... and counting, mostly around M dwarfs

→ ~40 billion HZ planets around M dwarfs in the Milky Way!

*HZ: Habitable Zone

*M dwarfs (“Red dwarfs”): Mass: 60% to 7.5% $M_{\text{sun}}$; Radius: 60% to 8% $R_{\text{sun}}$; Teff: 2,300 K to 3,800 K

Most exoplanets are to be found around M-dwarfs
M dwarf UV radiation affects the planet’s atmosphere (and observed spectrum)

Adapted from Rugheimer et al. 2015

Activity: Flares, spots, coronal mass ejections, Carrington events
UV activity in M-dwarfs is poorly known

- Requires long (days) stares
  - Longest Hubble observation: 2 days (non-continuous)
  - Longer observations are physically possible, but programmatically unfeasible.
- SPARCS will stare at 12 M-dwarfs for ~1 day to ~3 months

Example of analogous data stream (Kepler, active stars. 2 mo, 1 min. cad. Hawley et al. 2014).
SPARCS Payload and Bus

- 9 cm aperture, two-mirror telescope
- Dichroic + Two detectors
- Simultaneous observations FUV/NUV

- Notional design
- Bus vendor has not been selected
SPARCS Bandpasses

- Detectors are delta-doped CCDs (e2v). High UV response. JPL-developed technology
- FUV is a directly-deposited metal-dielectric filter: Strong red rejection
- NUV is commercial (Materion)

See Nikzad et al. 2012
SPARCS Orbit

- LEO, sun-synchronous terminator orbit.
- Benign thermal environment
- Long observing periods for some targets
- Launch opportunity has not been identified
Unique challenges for Astrophysics CubeSats

- **Astrophysics is signal-starved:**
  - SPARCS uses state-of-the-art UV detectors and a simple telescope design to achieve high sensitivity.

- **Exposures are long:**
  - Use well-characterized commercial ACS system: BCT XACT
  - Fast telescope to concentrate light in few pixels

- **Missions are long:**
  - Good mission assurance, selective redundancy, robust design

- **Doing the same will not sell:**
  - Exciting new science: Time-domain UV observations