

Roy T. Smart

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RESEARCH INTERESTS

- Solar transition region explosive events and jets
- Snapshot imaging spectroscopy
- EUV instrument design and optical modeling
- Ultraviolet response of silicon sensors
- Inverse problems and machine learning
- Open-source scientific software

EDUCATION

Ph.D. in Physics, Montana State University

Aug 2015 – May 2027 (expected)

Advisor: Charles Kankelborg

B.S. in Physics, Minor in Computer Science, Montana State University

Aug 2011 – May 2015

RESEARCH EXPERIENCE

Department of Physics, Montana State University

Jan 2016 – Present

Graduate Research Assistant, advised by Charles Kankelborg

Bozeman, MT

- **EUV Snapshot Imaging Spectrograph (ESIS).** A NASA sounding rocket computed tomography imaging spectrograph, which measures Doppler shifts across an 11.5 arcminute field of the transition region in a single exposure.
 - **Instrument paper.** Leading the instrument paper, a reproducible article generated from the instrument model.
 - **Optical model.** Developed the optical model of ESIS in Python, which predicts its distortion, vignetting, point-spread function, and effective area from measurements of its coatings, filters, and gratings.
 - **Flight preparation.** Developed the analysis used to align and focus the optics, generated the baffle apertures from the optical model, and measured the wavefront error and roughness of the primary mirror and gratings with phase-shifting interferometry.
 - **Calibration.** Built the pipeline that calibrates the flight images, including the characterization of the gain, dark current, and linearity of the CCD cameras built by NASA Marshall Space Flight Center.
 - **Science.** Inverted the flight images into spectral cubes using convolutional neural networks and the multiplicative algebraic reconstruction technique. Leading a study of a transition region jet which combines ESIS Doppler shifts with the magnetic topology from SDO/HMI and differential emission measures from SDO/AIA and Hinode/XRT.
 - **ESIS-II.** Helped design the optics of the second flight (2027), which adds channels and new spectral lines.
- **Silicon sensors in the ultraviolet.** Proposed partial charge collection as the reason that Hubble/WFC3 and IRIS measure less noise in the ultraviolet than photon shot noise predicts, with a model that agrees with both. Measured the depth-dependent charge-diffusion kernel of all four IRIS CCDs in orbit, using energetic particles that cross the sensors at glancing angles.
- **Full-sun Ultraviolet Rocket Spectrometer (FURST).** Contributed to the optical design and tolerance analysis of this NASA sounding rocket spectrograph of the Sun as a star. Modeled the instrument as built, from measurements of its flight grating, coatings, and filter, to predict its effective area and spectral resolution for the instrument paper.
- **Multi-Order Solar EUV Spectrograph (MOSES).** Measured Doppler shifts in MOSES-II images by tracking features between spectral orders, and trained neural networks on IRIS observations to invert MOSES images.
- **IRIS planner.** Chose the targets and observing programs of the Interface Region Imaging Spectrograph, and coordinated its observations with other observatories.

Department of Physics, Montana State University

Sep 2012 – Aug 2015

Undergraduate Research Assistant, advised by Charles Kankelborg

Bozeman, MT

- **MOSES-II.** Wrote the flight software that commanded MOSES-II and handled its data, and analyzed the thermal behavior of an optical mount.

SOUNDING ROCKET CAMPAIGNS

ESIS, White Sands Missile Range, NM: integration, testing, and flight operations

Sep 30, 2019

MOSES-II, White Sands Missile Range, NM: flight software and range operations

Aug 27, 2015

FELLOWSHIPS

NASA Earth and Space Science Fellowship (NESSF)

Sep 2017 – Sep 2020

Neural Networks for Computed Tomography Imaging Spectroscopy of the Solar Atmosphere

PUBLICATIONS

Published

- Longcope, D. W., & **Smart, R. T.** (2026). Using spectra to characterize the hot, dense ridge in a two-ribbon flare. *The Astrophysical Journal*, 1010(2), Article 193. <https://doi.org/10.3847/1538-4357/aea900>
- Parker, J. D., **Smart, R. T.**, Kankelborg, C. C., Winebarger, A. R., & Goldsworth, N. (2022). First flight of the EUV Snapshot Imaging Spectrograph (ESIS). *The Astrophysical Journal*, 938(2), Article 116. <https://doi.org/10.3847/1538-4357/ac8eaa>
- Johnson, M. A., Kankelborg, C. C., Meuchel, R., & **Smart, R. T.** (2018). Confocal microscopy for high-precision non-contact optical measurements. *Optical System Alignment, Tolerancing, and Verification XII*, 10747, Article 107470A. <https://doi.org/10.1117/12.2319597>

In preparation

- **Smart, R. T.**, Courrier, H. T., Parker, J. D., Kankelborg, C. C., Winebarger, A. R., et al. (in preparation). *The EUV Snapshot Imaging Spectrograph*. [Draft](#)
- **Smart, R. T.**, Kankelborg, C. C., Parker, J. D., & Longcope, D. W. (in preparation). *Flows, magnetic topology, and temperature of a transition region jet observed by the EUV Snapshot Imaging Spectrograph*. [Draft](#)
- **Smart, R. T.**, Kankelborg, C. C., & Parker, J. D. (in preparation). *The noise on ultraviolet astronomical images captured by back-illuminated silicon sensors*. [Draft](#)
- **Smart, R. T.**, & Kankelborg, C. C. (in preparation). *Measuring the charge-diffusion kernel of a back-illuminated CCD in orbit from glancing particle tracks*. [Draft](#)

SELECTED TALKS

- The Physical Structure and Evolution of Transition Region Explosive Events Observed with ESIS. *AAS SPD*, 2026.
- The Noise Measured by Back-Illuminated Silicon Sensors. *OpTeC* and *SPD*, 2025.
- Inverting ESIS Observations of the Solar Transition Region using Convolutional Neural Networks. *IRIS-Hinode*, 2024.
- Diagnosing Coronal Heating using Computed Tomography Imaging Spectroscopy. *ISSI team meeting*, 2023.
- A Convolutional Neural Network for Inverting Observations from ESIS. *Colloquium, LMSAL*, 2022.
- Analyzing ESIS Observations Using Convolutional Neural Networks. *Colloquium, NASA MSFC*, 2020.
- Machine Learning Techniques for Computed Tomography Imaging Spectroscopy of the Solar Atmosphere. *AGU*, 2018.

Also posters at AGU (2019, 2020) and the AAS SPD (2016, 2017). All talks, with slides, are at roytsmart.github.io/talks.

SOFTWARE

Author and maintainer of open-source Python packages for modeling instruments and analyzing solar data, each released on PyPI with a Zenodo DOI, tested in continuous integration, and documented online. Most are at github.com/sun-data.

named-arrays	Arrays with named axes and automatic propagation of uncertainties
optika	Raytracing and modeling of optical systems, similar to Zemax
ctis	Inversion of images captured by computed tomography imaging spectrographs
esis , furst , msfc-ccd	Models of the ESIS and FURST instruments and the MSFC CCD cameras
iris , sdo , hinode , utu	Analysis of IRIS, SDO, and Hinode data, and spectral lines from CHIANTI
aastex	Journal articles written as Python programs, so every number in the text is computed

SKILLS

Optics	Zemax OpticStudio, phase-shifting interferometry, alignment and focus, EUV coatings and filters
Detectors	CCD characterization: gain, photon transfer, dark current, linearity, charge diffusion
Solar data	SDO/AIA and HMI, IRIS, Hinode/XRT, CHIANTI, differential emission measures
Languages	Python, C/C++, CUDA, IDL, L ^A T _E X
Python	NumPy, SciPy, Astropy, SunPy, Numba, Keras, Matplotlib, pytest, Sphinx, GitHub Actions

TEACHING AND MENTORING

Mentor, ESIS undergraduate optics team

Graduate Teaching Assistant, Physics I laboratory

Aug 2015 – Dec 2015

PERSONAL INTERESTS

Alpine skiing, whitewater rafting, and amateur astronomy.

References are available on request.