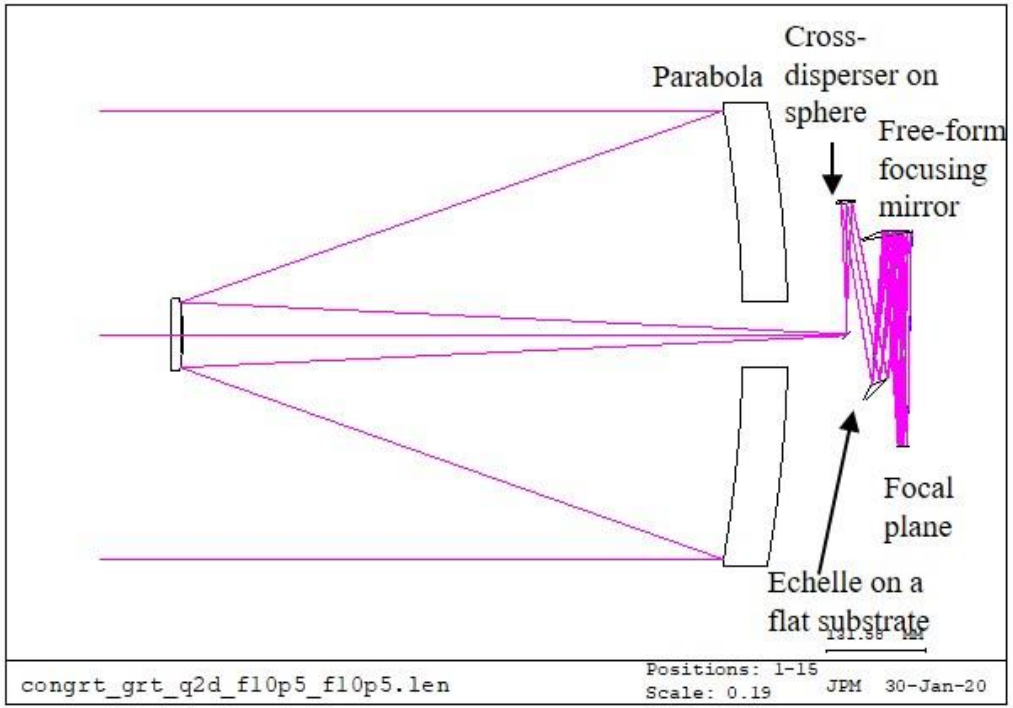


Virtual Research Presentation Conference

UV Spectrometer Brassboard

Principal Investigator: Jim McGuire (383)
Co-Is: Dan Wilson (389) and Steve Macenka (383)
Program: UV Instruments

RPC-149

Jet Propulsion Laboratory
California Institute of Technology

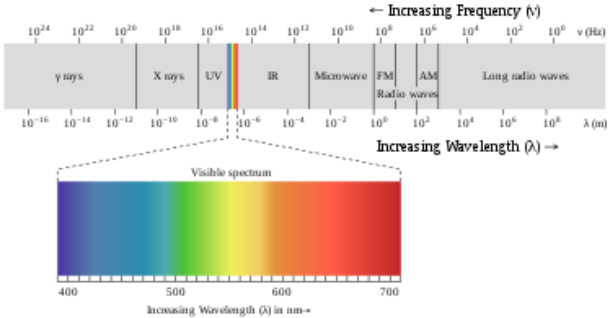
UV and UV astronomy

Electro-magnetic radiation is emitted over a wide range of wavelengths. The Ultra-Violet (UV) part of the spectrum has wavelengths just shorter than the human eye can perceive.

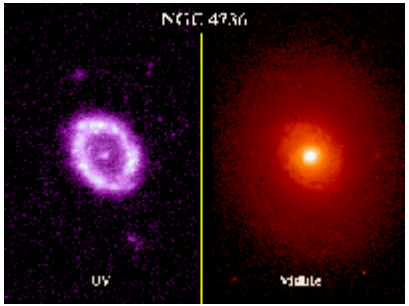
UV light is absorbed by the Earth's atmosphere, so measurements cannot be made from the ground. **UV spectrometers need to be space**.

From Wikipedia:

Ultraviolet line spectrum measurements (spectroscopy) are used to discern the chemical composition, densities, and temperatures of the interstellar medium, and the temperature and composition of hot young stars. UV observations can also provide essential information about the evolution of galaxies. They can be used to discern the presence of a hot white dwarf or main sequence companion in orbit around a cooler star.



Electromagnetic spectrum (Wikipedia)



Astro image of NGC 4736 (Spiral With Interior Ring)

Problem Description

a) Currently the most sensitive and highest resolution UV spectrometers are on Hubble Space Telescope (HST) (a 2B $FY1990 school bus sized observatory with a 2.4m aperture launched in 1990), which is nearing the end of its life. A replacement will be needed soon.

b) There is great interest in UV spectrometers for the MIDEX call expected in FY22 (6 concepts are being considered for the JPL portfolio). With a MIDEX budget expected to be under $300M, PIs will probably only be able to afford an observatory that is less than 3 m long with 1/15th of HST's aperture area. The system will need to be more efficient than HST to get HST class science on a MIDEX budget

   a) Shouleh Nikzad has demonstrated delta-doped detectors are 6x more efficient than heritage detectors and is raising them to TRL 6 on another SRTD

   b) John Hennessy is developing higher coating efficiencies on another SRTD

   c) Dan Wilson is are working on improved grating efficiency under this SRTD: gray-scale cross-dispersers and anisotropically etched echelle gratings. HST gratings are about a factor of 2 or more from theoretical efficiencies. Applying a 21st century e-beam technology will get us much closer to theoretical than HST gratings made by ruling (first made in the 19th century) or holographically (first made in the 20th century).

   d) We believe efficiencies within a factor of 2 of HST are within reach. Building and testing the brassboard with advanced detectors, coatings, gratings, and optical design will allow JPL to credibly propose astronomical UV spectrographs.

c) The upcoming MIDEX call will be the first opportunity to propose this technology. Looking forward, two of the proposals for great observatories (HabEx and LUVOIR) have UV spectrometers.

Methodology

a) Formulation

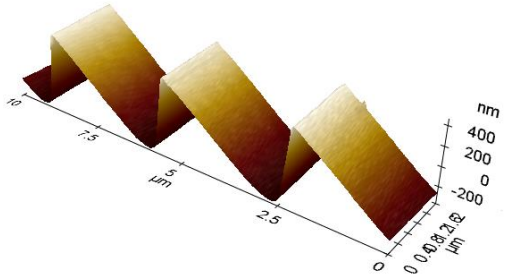
a) Flow down science requirements to optical requirements

b) Design smaller (lower cost) UV spectrographs

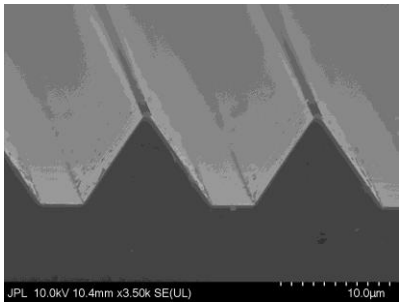
c) Fabricate improved UV gratings with an e-beam

b) Innovation, advancement

A new UV-SCOPE design has straight echelle grooves on a flat surface, which are similar to previously fabricated gratings (although at poor efficiency). This is a significant simplification over the old UV-SCOPE designs, which had an echelle grating on a mild freeform surface or an echelle grating with curved grooves on flat grating, both of which lacked good fabrication heritage.



RTD grayscale echelle
~50% theoretical efficiency



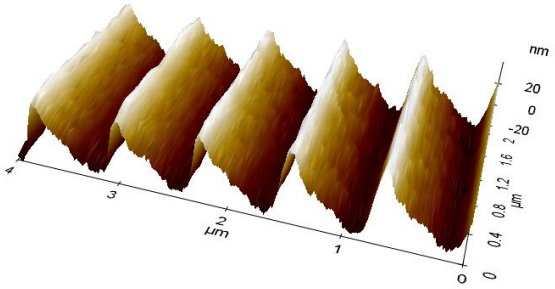
UT Austin (JPL partner) anisotropic etched grating

Results

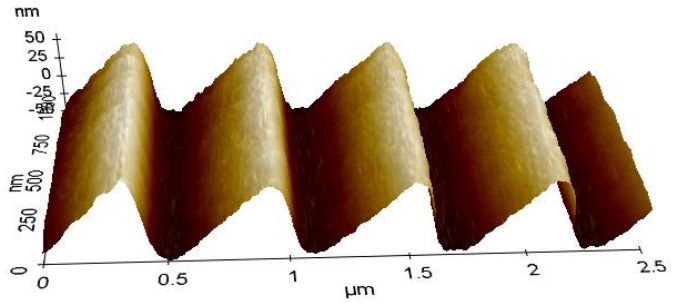
a) Accomplishments versus goals: We successfully designed a spectrometer for UV-SCOPE with easier to manufacture gratings that are compatible with e-beam grating writing. We iterated the cross-disperser grating fabrication once. We obtained substrates for developing higher echelle efficiency gratings. Unfortunately, we were unable to manufacturing echelle gratings due to flight priorities at MDL, COVID, and then fires shutting down MDL. Without understanding of the grating limitations, we did not finalize the optical or opto-mechanical designs as planned.

b) Significance: We better understand what gratings need to be fabricated and are ready start work.

c) Next steps: Fabricate UV echelle gratings, further improve the cross-disperser gratings, and buy optics necessary to build spectrometer brassboard(s).



RTD cross-disperser



New cross-disperser

Publications and References

None this year