

## Explanatory Guide and Acknowledgements: NASA Electromagnetic Spectrum & Infrared Astronomy (EMS/IRA) Curriculum Components

NASA's Science Mission Directorate required focus on student learning outcomes as a condition for establishing the AAA cooperative agreement with the SETI Institute in 2016. In response, AAA staff produced an NGSS-aligned, NASA content-oriented electromagnetic spectrum & infrared astronomy (EMS/IRA) curriculum unit to enhance student science learning and STEM engagement. The curriculum is designed using constructivist learning theory in accordance with Next Generation Science Standards (e.g. *Next Generation Science Standards: For States, By States*. Washington, DC: The National Academies Press, 2013).

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Instructors intending to implement any portion of the curriculum should keep the following important points in mind:

- The curriculum was written with the intent that it will be used by fully trained AAA teachers. Before teaching the curriculum, AAA teachers receive six months of focused professional development, an all-day in-person curriculum training workshop, and a STEM immersion experience.
- The curriculum is based on a series of hands-on student activities. Materials and equipment needed for those activities are listed in the lesson plans.
- The curriculum materials are not in final form. These materials are still undergoing revision; there has not yet been an independent product review.

### CURRICULUM MATERIALS AVAILABLE:

#### 1) All Days Unit Overview and Misconceptions (pdf file)

An overview of the entire 10-day EMS/IRA curriculum including teaching goals, NGSS cross references, lists of materials and resources needed, and two articles regarding common student misconceptions about light, vision, and EM radiation.

#### 2) All Days Unit Overview and Implementation Slides (pdf version of ppt file)

Includes images and graphics necessary for implementation of the curriculum.

#### 3) Day-by-day curriculum lesson plans (pdf files)

Detailed teacher guides and lesson plans for the 10 days of the AAA EMS/IRA curriculum, including materials for classroom handouts & demonstrations.

Days 1+2 Lesson Plans (Filters and Wavelengths)

Day 3 Lesson Plan (Beyond the Visible)

Days 4+5 Lesson Plans (Detecting the Invisible)

Day 6 Lesson Plan (How Do Astronomers Use Images in Research?)

Days 7+8 Lesson Plans (How Do Astronomers Use Spectra in Research?)

Days 9+10 Lesson Plans (How Do Scientists Know What They Know?)

#### 4) Science Case Studies student reader (pdf files)

Student reader booklet supporting the EMS/IRA curriculum, available in English and Español. Contains an infrared astronomy overview, glossary of scientific terms, and five “case studies” of research projects conducted by scientists using SOFIA, NASA’s Stratospheric Observatory for Infrared Astronomy.

Infrared Astronomy Case Studies Reader [English]

Astronomía Infrarrojo Estudio de Casos Científicos [Español]

#### 5) IR Astronomy & SOFIA mission lithographs (pdf files)

Public engagement handouts that support the EMS/IRA curriculum.

(Orion) Infrared Astronomy: More Than Our Eyes Can See [English]

(Orion) Astronomía Infrarrojo: Más De Lo Que Nuestros Ojos Pueden Ver [Español]

SOFIA: Exploring the Infrared Universe [English]

SOFIA: Explorando el Universo Infrarrojo [Español]

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For any questions about the EMS/IRA curriculum unit, contact NASA Airborne Astronomy Ambassadors project staff:

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### Acknowledgements

The NASA EMS/IRA curriculum module was produced in 2016-17 by SETI Institute AAA staff members Coral Clark, Pamela Harman, and Dana Backman with significant contributions from Airborne Astronomy Ambassador Theresa Moody.

Some of the hands-on activities in the EMS/IRA curriculum module are derived from the Active Astronomy: Classroom Activities for Learning About Infrared Light developed in 2002 by the SOFIA Education & Public Outreach Team and the Conceptual Astronomy and Physics Education Research (CAPER) Activities Development Team at Montana State University.

We would like to thank the following AAA teachers and their students for their critical comments and recommendations based on their classroom use of these activities which contributed to this curriculum module. Their participation in the development does not necessarily imply endorsement of the module. Their recommendations were invaluable and have been integrated into the activities.

### Pilot Test Teachers

Jeff Baldwin  
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### Initial Implementation Districts

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Campbell Union High School District, Campbell, Calif.  
Manteca Unified School District, Manteca, Calif.  
Vista Unified School District, Vista, Calif.  
Anaheim Union High School District, Anaheim, Calif.  
Santa Clara Unified School District, Santa Clara, Calif.  
East Side Union High School District, San Jose, Calif.