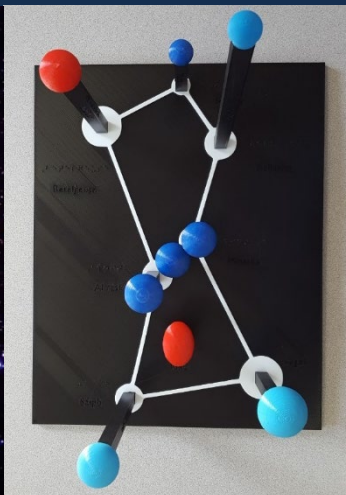


# *Accessible Astronomy: Using 3D Printing to Teach the Wonders of the Universe to Students with Visual Impairments*

Thomas Madura

Department of Physics & Astronomy  
San José State University



# The Problem

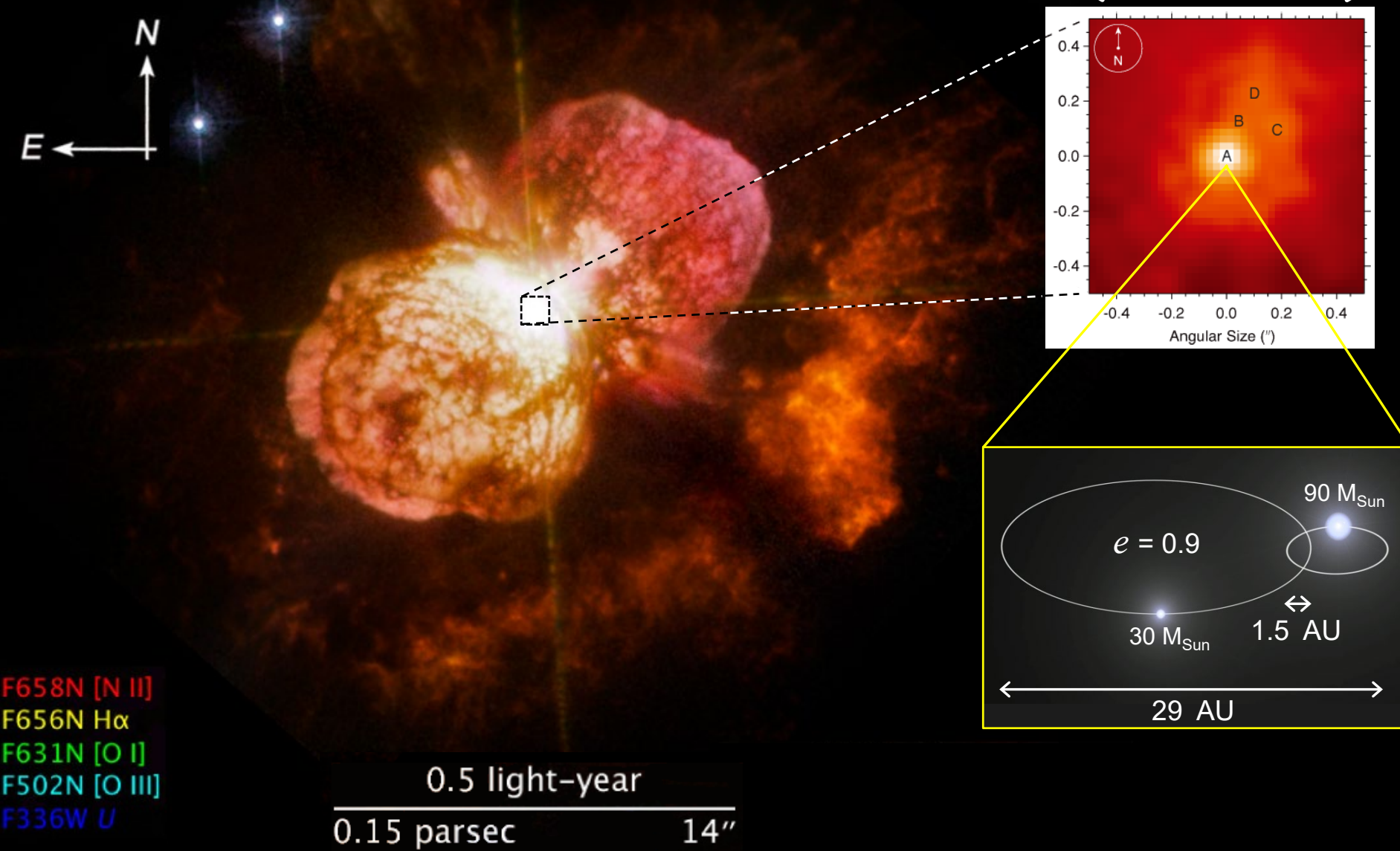
- Nearly everything we know about the Universe comes from studying light and running computer simulations.
  - Most astronomy data consist of 2D images or spectra, even though the Universe is at least 4D.
1. Can we do better than pretty pictures?
  2. Can we teach the wonders of the Universe to those with visual impairments?

***YES!***

$\eta$  (Eta) Carinae  
HST WFPC2  
 $D = 7500$  light-years  
(Credit: NASA, ESA, and  
Hubble SM4 ERO Team)

# Eta Carinae: A Case Study in 3D Astronomy

(see e.g. Madura 2017)



# The 3D Structure of the Homunculus

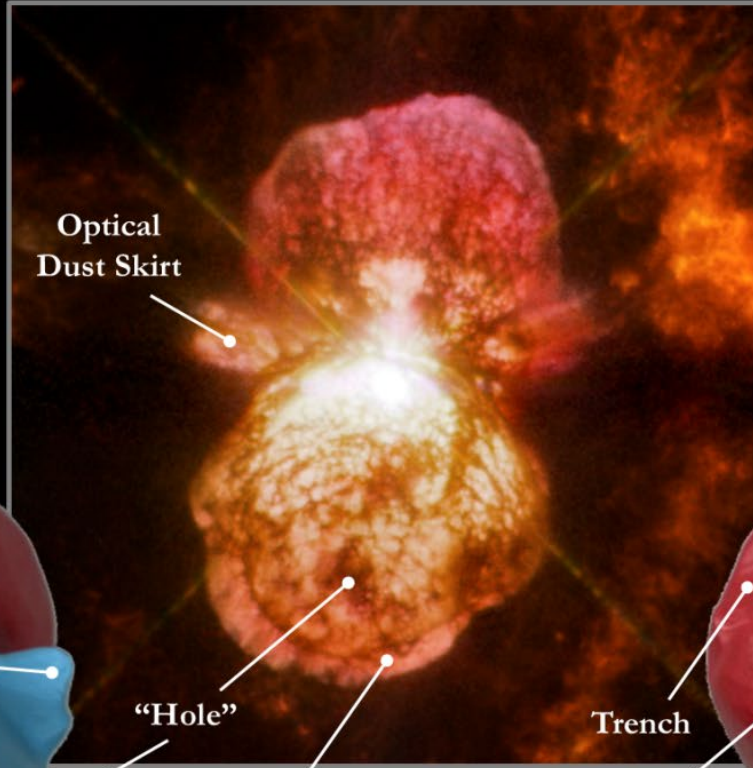
Full spectral mapping (2990 Å – 24,790 Å) of the entire Homunculus Nebula in March 2012 with the Very Large Telescope in Chile.

Assemble a data cube. Focus on molecular hydrogen infrared emission, which traces fronts *and* backs of lobes.

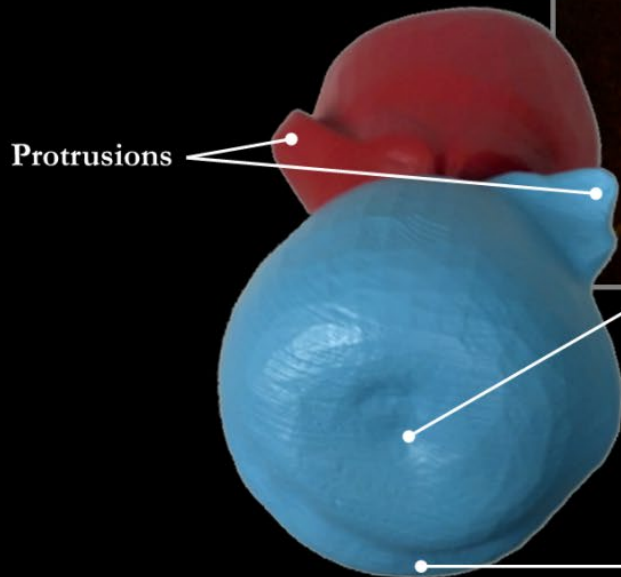




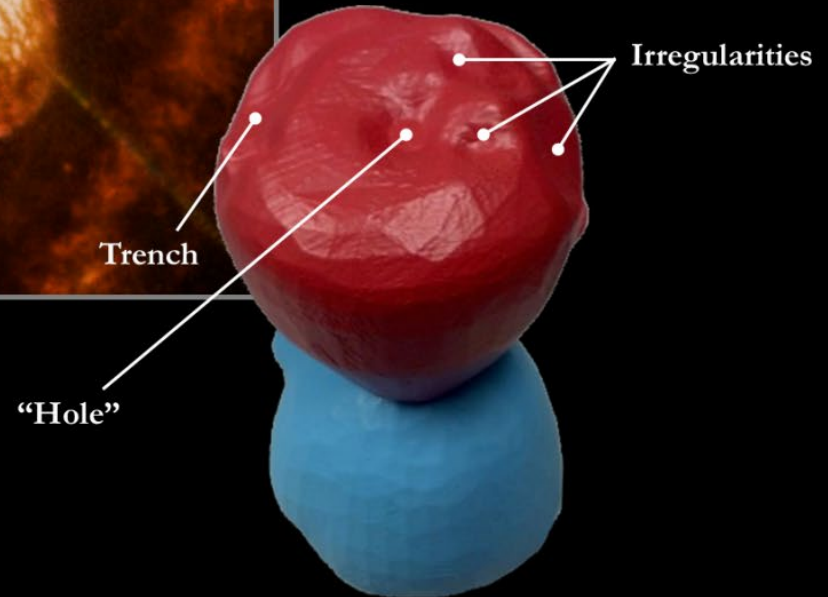
# Eta Carinae Homunculus Nebula



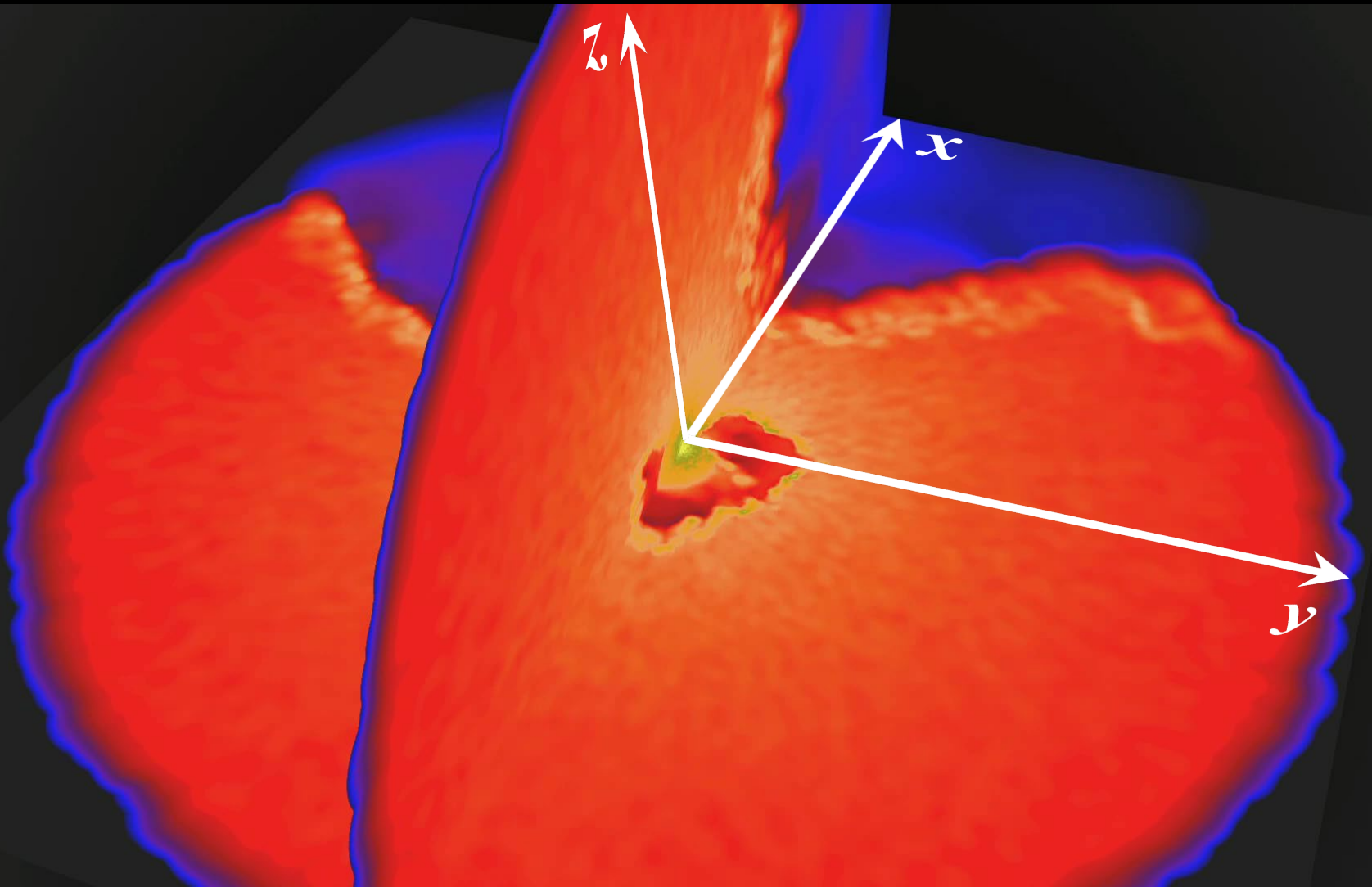
3D Print Model  
Side facing toward Earth



3D Print Model  
Side facing away from Earth

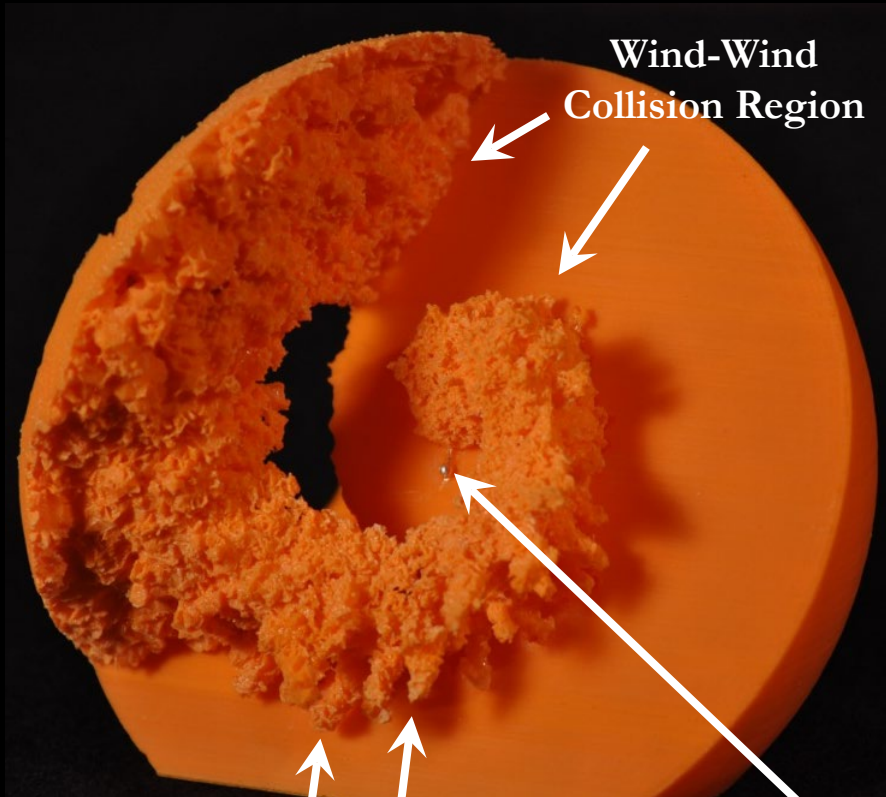


# The 3D Structure of the Colliding Winds



# 3D Printing the Wind-Wind Collision Region

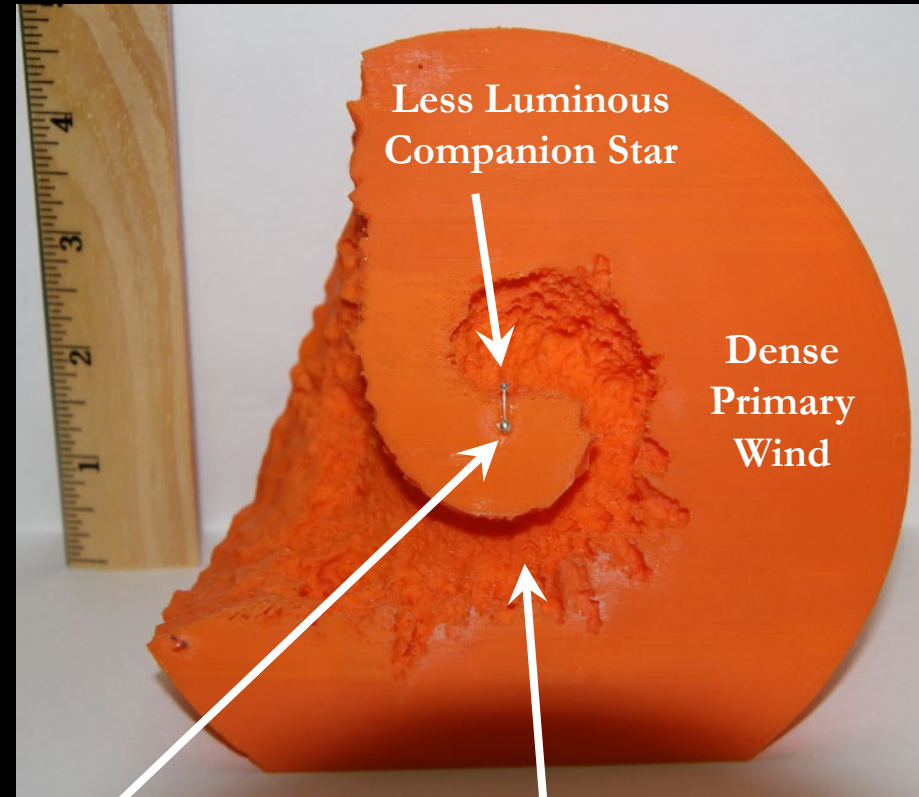
3 Months After Closest Approach of the Stars  
Looking Down on the Orbital Plane



Wind-Wind  
Collision Region

Newly Identified  
Finger-like Protrusions

More Luminous  
Primary Star



Less Luminous  
Companion Star

Dense  
Primary  
Wind

Wind Cavity Carved  
by Companion Star



# 3D Printing the Wind-Wind Collision Region

View from  
Earth

View from above  
orbital plane

View looking  
into wind cavity

**apastron**

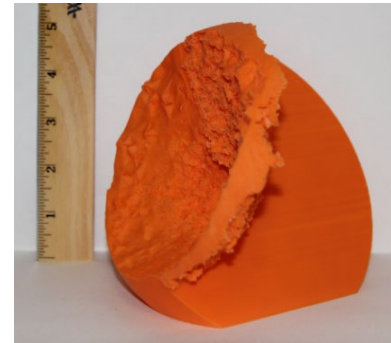
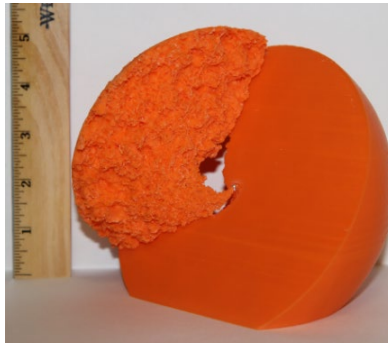
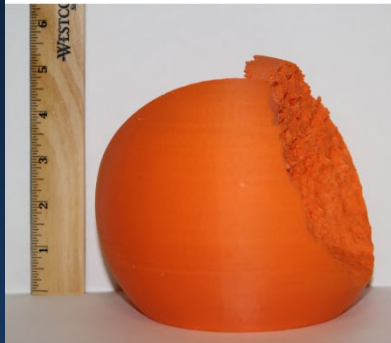
(when stars are  
farthest apart)



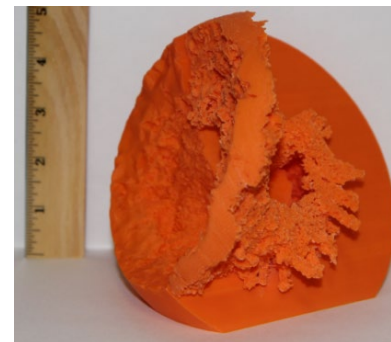
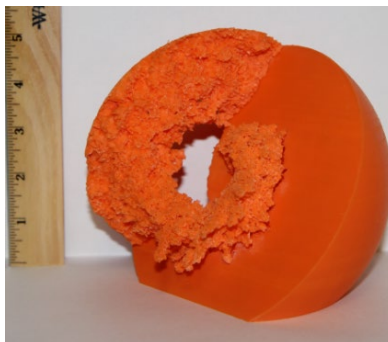
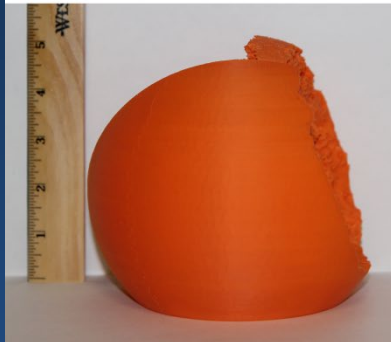
Scale:  
1 inch  $\approx$   
35.5 AU  $\approx$   
3.3 billion miles

**periastron**

(stars closest  
together)



**3 months  
after  
periastron**





# Enormous Outreach & Education Impact



## STEM Career Exploration Week:

SCCB: June 19<sup>th</sup> – 23<sup>rd</sup> 2017

July 23<sup>rd</sup> – 27<sup>th</sup> 2018

## Purpose:

Use 3D printing technology to help high school students that are visually impaired explore STEM careers using 3D tactile models and sonification, and to introduce students to professional role models that are blind and who have successful STEM careers.



# Enormous Outreach & Education Impact

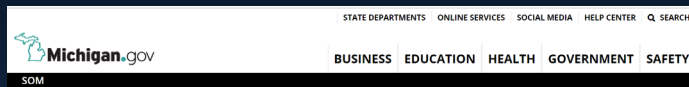




# Enormous Outreach & Education Impact



## Michigan Bureau of Services for Blind Persons STEM Career Exploration Week: June 18<sup>th</sup> – 22<sup>nd</sup> 2018 3D Printer Kit-Build Weekend: September 7<sup>th</sup> – 9<sup>th</sup> 2018



### Blind and Visually Impaired Students Explore Careers at Unique STEM Camp

BSBP Training Center works with NASA to host first-ever career exploration lab

Media Contact: LARA Communications 517-373-9280  
Email: [mediainfo@michigan.gov](mailto:mediainfo@michigan.gov)

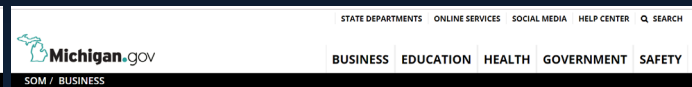
**July 17, 2018** - From meteorites and Mars, to the sun and the moon, blind and visually impaired students from around the state explored the galaxy at a unique weeklong career exploration lab (CEL) held recently at LARA's Bureau of Services for Blind Persons (BSBP) Training Center in Kalamazoo. Offered under BSBP's Pre-Employment Transition Services, the program featured a NASA engineer, and scientist presenters who introduced astronomy concepts to the students utilizing 3D technology and tactile graphs.

"This was an invaluable experience that gave our students an early start in identifying career interests in the sciences," said BSBP Director Bill Robinson. "The program also provided us with a greater understanding of how to better serve the STEM educational needs of our students."

BSBP is only one of two vocational rehabilitation agencies in the nation\* to have worked with NASA on offering the career exploration lab. The CELs are being implemented around the country for blind and visually impaired students as part of a research study aimed at how to better assist high school students with blindness/visual impairments, and their teachers, as they learn STEM subjects and potentially pursue a STEM career. These CELs use a student-centered, hands-on approach, 3D printing technologies, and 3D printed models to teach a variety of astronomy topics that target the spatial thinking skills of students with blindness/visual impairments.

Featured speaker Ken Silberman, NASA engineer and registered patent attorney, spoke about his personal experiences as a blind student pursuing a STEM education and career. Classes were taught by scientists. Dr. Thomas Madura, assistant professor, Department of Physics and Astronomy, San Jose State University, who spearheaded the project, and Dr. David Hurd, professor of Geosciences and Planetarium director at Edinboro, University of Pennsylvania, provided multiple NASA Braille and tactile publications used in the training. Additional scientists presenting were Dr. Carol Christian, Hubble Space Telescope Outreach Project scientist, Space Telescope Science Institute, Baltimore, MD; and Dr. Wanda Diaz-Merced, astronomer and computer scientist. Students also visited the Kalamazoo Valley Museum and its planetarium.

The **BSBP Transition Program** helps students age 14 – 26 successfully transition from high school to postsecondary education or employment based on the student's goal. Pre-employment transition services are provided in collaboration with local educational agencies and community partners. The program includes five pre-employment transition service categories: job exploration counseling; work-based learning;



### Blind Students Gain Employability Skills at First-Ever 3D Kit Build Print Weekend at BSBP's Training Center in Kalamazoo

Media Contact: LARA Communications 517-373-9280  
Email: [mediainfo@michigan.gov](mailto:mediainfo@michigan.gov)

**September 13, 2018** - "I can print that!" This past weekend in Kalamazoo 11 blind and visually impaired students were visualizing in 3D using models printed from 3D printers that each student assembled from a kit.

LARA's Bureau of Services for Blind Persons (BSBP) and its Training Center in Kalamazoo, hosted a first-ever 3D Print Weekend for students to develop workplace readiness skills for the 21<sup>st</sup> century.

"The weekend was a first of its kind in the nation," said the Bureau of Services for Blind Persons (BSBP) Director Bill Robinson. "I am extremely proud of our Pre-Employment Transition staff who worked hard to plan the event."

Express Printing Solutions sponsored the 3D kit build weekend. Sean Nagle, President and CEO; Chance Scott, Vice President, and Kyle Mendez, Director of Mechanical Operations, all were present Saturday providing technical assistance as needed. Sean Nagle, who served in the Army and recently founded this fast-growing start-up stated, "We hope the impact to the community provides the opportunity to expand this innovative program to other organizations, allowing other students to be inspired with their own 3D printer. A big thanks to BSBP for the opportunity and we wish the students the best of luck with their printing endeavors." Robinson praised the partnership with a local

Kalamazoo business, "It is extremely satisfying to meet someone like Sean who is willing to give back to the community. It is also important that businesses engage with BSBP to develop talent for the 21<sup>st</sup> century Michigan workforce."

Also lending technical assistance and assisting with the curriculum was Dr. Thomas Madura, professor of Physics and Astronomy, San Jose State University. Dr. Madura exclaimed "The hands-on 3D printer program organized by the BSBP and Express Printing Solutions is an amazing and exciting new way to motivate students with visual impairments to pursue STEM. As far as I am aware, this is the first time a program such as this, where students with visual impairments assemble, test, and get to keep their own 3D printer, has been tried anywhere in the world. I am honored to be able to be involved in such a project." Dr. Madura was a key contributor to the development of this unique event as well as a key contributor to the STEM camp that BSBP sponsored earlier this summer. Click [here](#) to read the LARA Press Release on the STEM Camp held earlier this summer.



Shannon McVoy, BSBP's statewide transition coordinator, stated, "Science, Technology, Math and Engineering (STEM) programming is extremely important to the students BSBP serves."





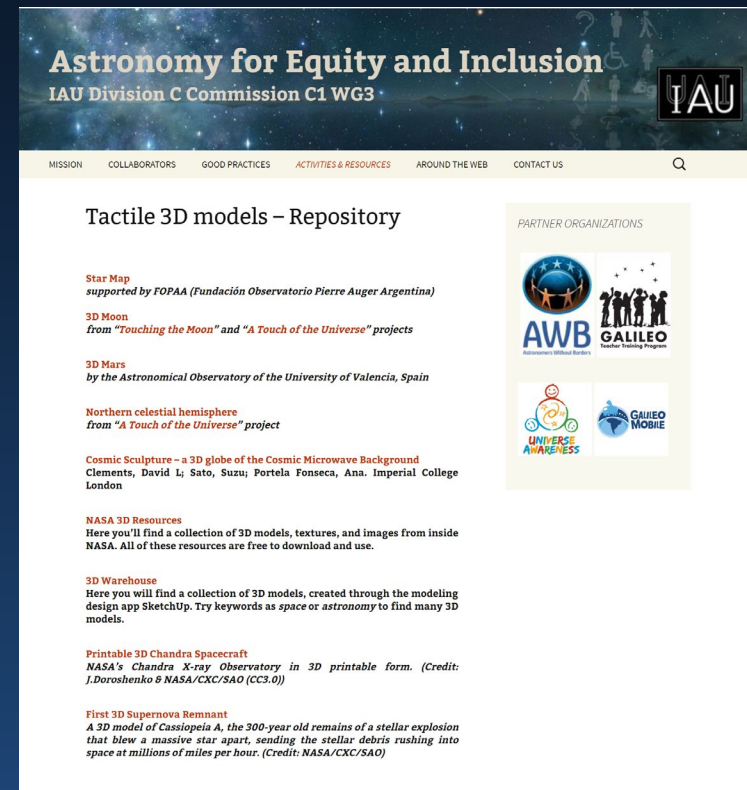
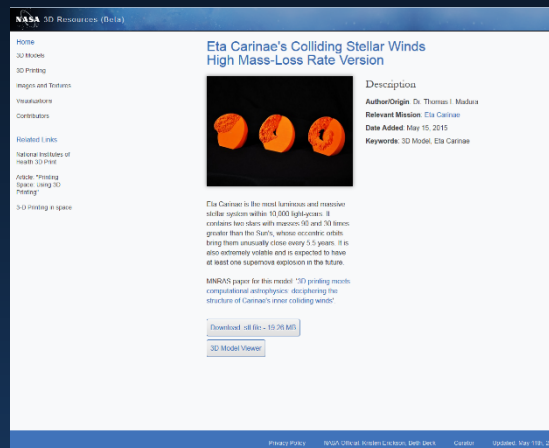
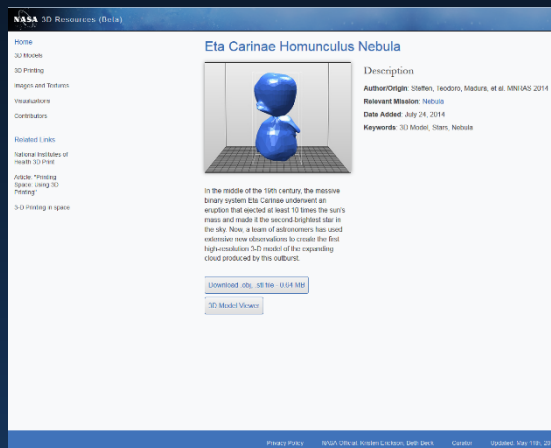
# Enormous Outreach & Education Impact

## IAU “Inspiring Stars” Exhibition, Vienna, August 2018



# Some 3D Models Freely Available via NASA and IAU Websites

<http://nasa3d.arc.nasa.gov/>  
<http://sion.frm.utn.edu.ar/iau-inclusion/>



<http://nasa3d.arc.nasa.gov/detail/eta-carinae-homunculus-nebula>

<http://nasa3d.arc.nasa.gov/detail/eta-carinae-high>

[http://sion.frm.utn.edu.ar/iau-inclusion/?page\\_id=647](http://sion.frm.utn.edu.ar/iau-inclusion/?page_id=647)

# The Next Steps

- Secure funding and make more models/lessons
- Extend to more schools
- Share what we learn and make
- Accessible 3D Printers and CAD Software?



# *Thank You!*

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