

# Astronomical Outreach Through Visual and Interactive Demonstrations

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## Abstract

Science Theatre is a science outreach program run by undergraduates at Michigan State University aimed to educate and excite the public about science. Currently the organization has created and is further developing an hour long presentation focusing on important concepts in astronomy such as solar system scale, phases of the moon, seasons, comets, and craters. In order to effectively engage K-12 students, Science Theatre will use visual and interactive demonstrations which break down the concepts into simple and easily accessible components that are modified in accordance with the age level and curriculum. For example, to teach students about the composition of a comet, Science Theatre performers will guide students through the construction of a small model comet using materials and a recipe provided by Science Theatre. The demonstrations are designed and documented so they may be performed by undergraduate volunteers at MSU, who may not have an extensive background in astronomy, with only limited training. Science Theatre will perform this show at no cost to schools across Michigan using materials and methods to which educators may not otherwise have access.

## Science Theatre

www.sciencetheatre.org  
sciencet@pa.msu.edu

### Background:

- Founded at Michigan State University (MSU) in 1991
- Stage and hands-on performances of interactive science demonstrations
- Content customized individually for all interests and age levels
- Performances made free of charge

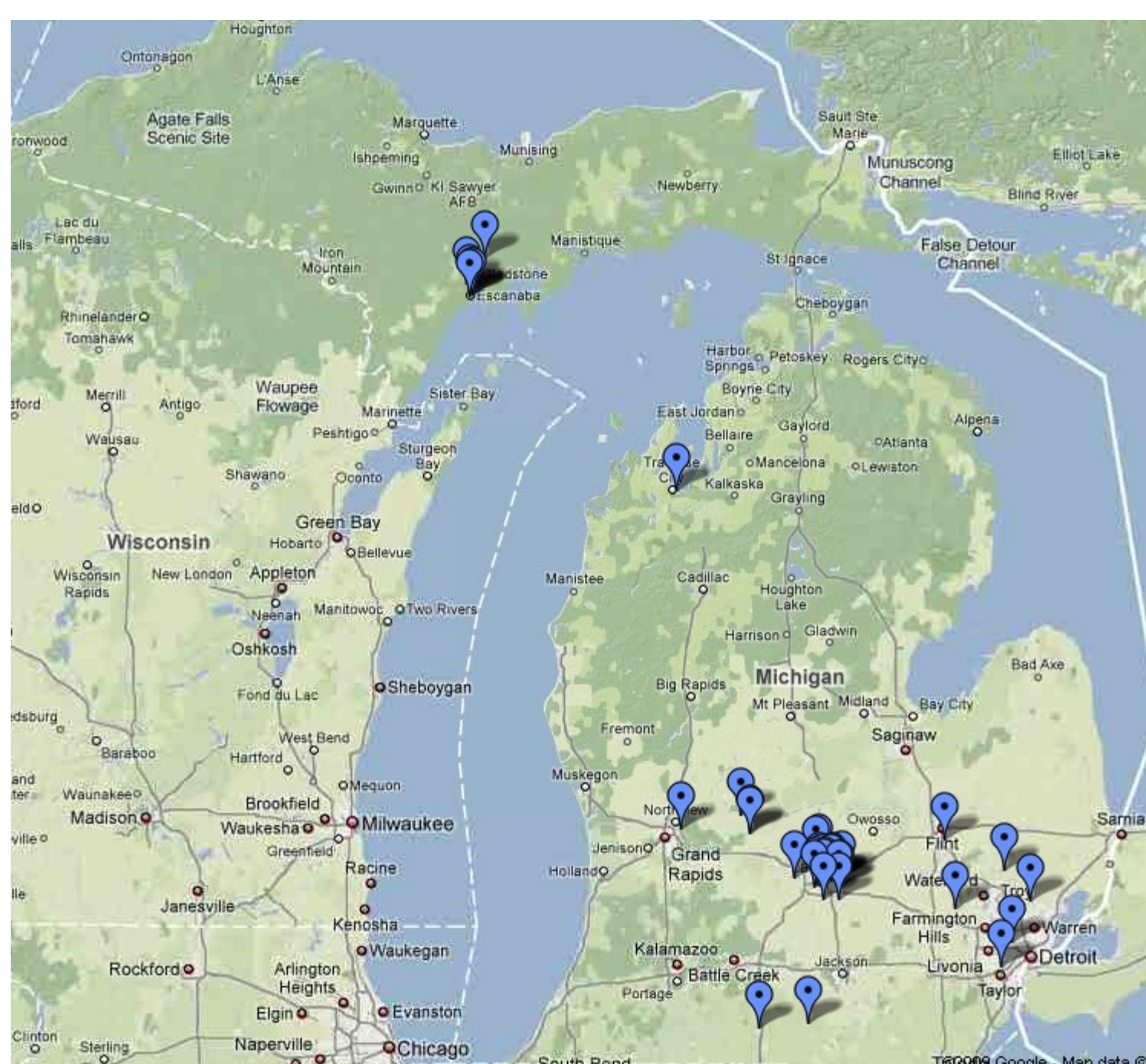
### Methods:

- Performances at ~50 schools and events across Michigan in 2009
- Organized and staffed by ~50 undergraduate volunteers
- A repertoire of more than 60 demonstrations in biology, chemistry, and physics

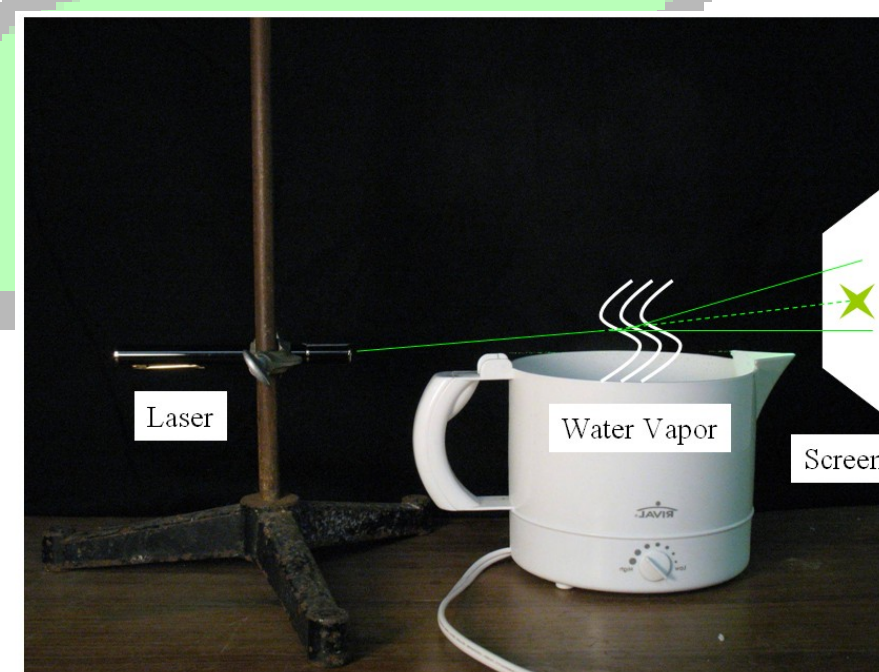
### Awards:

- National Science Foundation Grant (1991)
- AAAS Award for Public Understanding of Science and Technology (1993)
- The American Institute of Physics Meggars Award for enhancing the quality of physics education (1993)
- Michigan State University Department of Physics and Astronomy Outreach Award (1992, 1997, 1999, and 2009)
- 4 awards from the MSU Department of Student Life, including Outstanding Service Organization (2009)

## Performances in 2009



## Example Demonstrations



### Twinkling Stars<sup>2</sup>

**Concept:** Atmospheric effects on ground-based observations (astronomical seeing)

**Background:** The twinkling star effect seen by the eye is due to light passing through turbulent air of different temperatures in the atmosphere. Changes in the index of refraction of the atmosphere cause stars to appear to twinkle and detract from the resolution of astronomical images.

**Procedure:** A laser beam is passed over the top of boiling water and observed to shift randomly on a screen placed a short distance away.



### Doppler Ball

**Concept:** Doppler effect

**Background:** The change in the wavelength (color) of light due to motion along the line-of-sight is analogous to the change in apparent frequency (pitch) of sound waves – the Doppler effect. Astronomical applications of radial velocity determination including the detection of extrasolar planets and binary stars, rotational speed measurements, and Hubble's law are discussed.

**Procedure:** A single-tone buzzer is embedded in a foam ball. A game of catch allows students to hear increases and decreases in pitch as the ball is thrown.



### Solar System Scale

**Concept:** The relative size of Earth in the solar system and the galaxy

**Background:** A sense of the scale of the solar system is an important foundation for the exploration of nearly every astronomical concept. An appreciation for the relative size and distances between the sun, terrestrial planets, and gas giants leads to a discussion of extra solar planets, the distribution of stars in the Milky Way, and other astronomical objects.

**Procedure:** Wooden models have been cut to scale (Earth radius = 1 cm) and painted to represent the planets of the solar system and the sun. They are displayed together to illustrate size disparities. At this scale, 1 AU = 235 m and Neptune's orbit is at a radius of ~ 7 km.

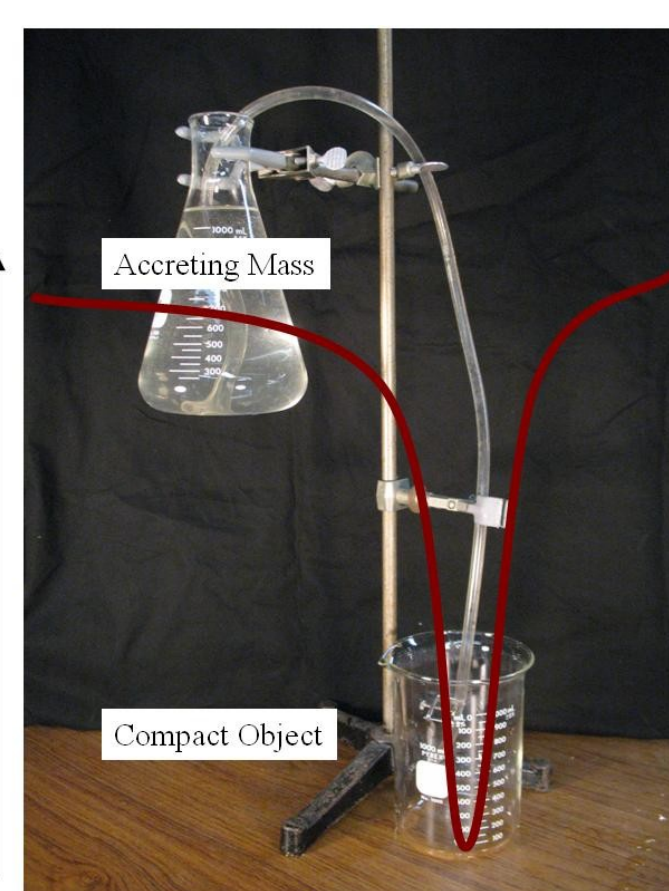


### Build a Comet<sup>1</sup>

**Concept:** An interactive model of a comet

**Background:** The composition of comets can be explored through hands-on activities. Comets consist of a small (~10<sup>4</sup> m) nucleus of water ice and frozen gases, dust, organic compounds, and other materials, a much larger (~10<sup>8</sup> km) spherical coma produced by solar heating upon entry to the inner solar system, and an enormous (~10<sup>9</sup> km) tail produced by the solar wind. Remote spectroscopy of comets and spacecraft flyby missions can be discussed.

**Procedure:** Students create a mixture of dry ice, water, sand/dirt, and organic coloring in a spherical bowl. A hair dryer is used to illustrate coma formation.

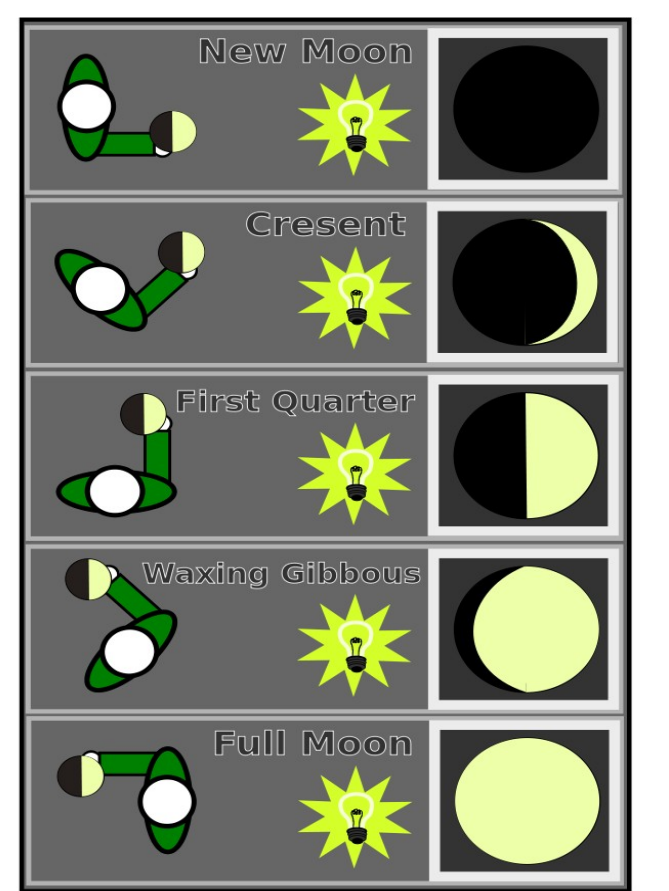


### Mass Transfer

**Concept:** Accretion and gravitational potential wells

**Background:** In binary systems, mass transfer can be initiated when the surface of one star fills the Roche lobe described by its gravitational equipotential and spills over onto its more-compact partner. Mass accretion may trigger classical (recurring) novae or supernovae. Accretion processes are fundamental to solar system and galaxy formation.

**Procedure:** An indicator solution is allowed to fall from one beaker onto another, prompting a color-changing reaction representing a type Ia supernova. Gravitational potential concepts and Lagrangian points are discussed as solution is allowed to fall from one beaker to the other. An oscillating reaction can be used to illustrate recurring novae and a chemiluminescent reaction to illustrate X-ray binaries.



### Moon Phases

**Concept:** An interactive model of the geometric origin of the phases of the moon

**Background:** The phases of the moon will already be familiar to students of all ages, but their relationship to the geometry of the solar system can be challenging. A simple hands-on activity can provide students with a strong understanding of a spatially-dependent phenomenon that can be used to introduce quasars, pulsars, extrasolar planet observation, and the projection of galaxies.

**Procedure:** In a darkened room, students stand around a bright lamp (without a shade) while holding a styrofoam ball at arms length. The students play the part of observers on Earth and find that, while the lamp (sun) illuminates half of the ball (moon) at all times, their viewing angle determines the apparent phase of the moon.

### Crater Box<sup>3,4</sup>

**Concept:** An interactive model of impact phenomenon and crater formation

**Background:** Impact phenomenon are a powerful tool for linking familiar astronomical observation (the naked-eye lunar surface) with more exotic processes (meteor showers) as well as other fields of science (geology). Crater features are dependent on the impactor size, surface and impactor composition, and trajectory.

**Procedure:** Steel balls are dropped above a sandbox. The composition and layering of sand and powders can be varied to simulate the formation of different crater types and different planetary surfaces.

## Concept Map

The Science Theatre astronomy show is a modular collection of demonstrations focusing on a variety of astronomical concepts that can be integrated into performances for varying age levels.



Each terminal entry in the map is a demonstration that has been developed for Science Theatre's Astronomy Show.

## Future Work

### Content development:

- Equipment construction
- Documentation writing
- Visual illustrations or human-modeling of additional concepts, including:
  - Blackbody radiation
  - Stellar evolution
  - Big Bang cosmology

### Performances

- Two performances of the Astronomy Show planned for 2010
- Integration of individual demonstrations into broader performances

## References

1. "Cookin' Up a Comet." NASA Stardust Educator's Guide.
2. Reeve, S. "Twinkling Stars." Saint Mary's University Department of Astronomy and Physics.
3. Uehara, J.; Ambroso, M.; Ojha, R.; Durian, D. Phys. Rev. Lett. 90, 194301
4. Walsh, A.; Holloway, K.; Habdas, P.; de Bruyn, J. Phys. Rev. Lett. 91. 104301.

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