

CREATIVE TEACHING WITH ASTRONOMICALLY INSPIRED MUSIC

Using music to
expand students'
astronomical
horizons.

by **Matthew Whitehouse**



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Courtesy Astronomical Society of the Pacific

A bluish nebula of glowing hydrogen expands out into the remains of the molecular cloud that collapsed to form the massive stars in this region known as LH 95, located in the Large Magellanic Cloud. Image courtesy NASA / ESA / Hubble Heritage Team (STScI / AURA)

Imagine that you are sitting on the floor in the dome of a large scope — perhaps the 2.3-meter [Bok telescope](#) at Kitt Peak National Observatory. You're at The University of Arizona's Astronomy Camp, and sunset's glow is fading — time for the nightly dark-adaptation music presentation.

Following a few logistical announcements, the dome lights dim to red and a brief explanation of the night's dark-adaptation music selection commences. The dome lights are then turned out completely, and the music begins to play. This piece is more unusual than the selections from the preceding nights of Camp, and you find the music almost perplexing.

After the music finishes, you join in a discussion regarding the ways in which you think the music connects with astronomical concepts. The whole experience leaves you ready to “let your mind start a journey through a strange new world,” to quote from Andrew Lloyd Webber's “Music of the Night.”

A Musical Approach

Since 2006, I have helped students explore the connections between music and astronomy for the UA's [Astronomy Camp](#). This exploration takes the form of a series of 15- to 20-minute presentations at the beginning of each night of Camp. These presentations take place in the telescope dome, in the dark, and allow campers time to become dark adapted before beginning the night's observing activities.

My background is musical; I am an organist and composer completing my doctorate in music at The University of Arizona. Astronomy, particularly astronomy education, is my second passion. As a composer, my work is frequently inspired by astronomical concepts and phenomena. I'm a former student in the Astronomy Camp program and returned to the program as a counselor when I came to Tucson for graduate school. Additionally, I volunteer for Project ASTRO-Tucson.

Astronomy Camp emphasizes a broad, interdisciplinary approach to science engagement. Campers participate in hands-on, interactive activities that explore not just astronomy but also related areas such as physics, engineering, and mathematics. Campers often have arts backgrounds — many sing, play a musical instrument, or are involved in other areas of the performing and visual arts. Given campers' backgrounds and the program's broad approach to science education, the program is an ideal setting for exploring connections between music and astronomy.

Expanding Students' Horizons

One of the first decisions I made while designing Camp music programming is that it should be both a scientific *and* artistic exploration. In other words, musical selections should not just reinforce science concepts; they should also expand students' awareness of the creative aspects of music. Presentations are designed to stretch students and introduce them to music that may be new to them. Most of the selections are 20th- or 21st-century “classical” music, including my own compositions.



The Mayall 4-meter telescope looms large in the left foreground. To its right is the 2.3-meter Bok telescope, noteworthy for being tubular and not a dome. In the far background is the triangular shape of the McMath-Pierce solar facility.

NOAO / AURA / NSF

In the spirit of stretching students and expanding their artistic awareness, I typically present pieces in their entirety. Large-scale or multi-movement works are an exception, and in such cases I present a single movement or section. These decisions are made so that the musical integrity of the composition is preserved as much as possible. Pieces that are easier to grasp are presented near the beginning of the week, with musical offerings becoming increasingly challenging as the Camp progresses.

Each evening's music presentation is similarly structured. It begins with a brief introduction to the composition, the composer, and the science concept that serves as an inspiration for the piece. Following this preliminary explanation, I play a recording of the composition. After students listen to the piece, I facilitate a discussion about the ways in which science and music connect and encourage the students to ask questions about the music.

One technique I frequently use in my introductory talk is *avoiding* a discussion of specific ways in which music and science intersect. Instead, I help students establish a basic understanding of the scientific concept behind the composition, but I don't say much about the ways in which that concept serves as inspiration for the piece. My goal is to have campers form their own connections while listening to the music, and for them to share the connections they've made.

This approach encourages students to think critically about the selection, and transforms the post-listening discussion into a creative experience. I have found that students often establish cogent science/music connections themselves and frequently share insights about the piece that I had not previously considered. If needed, I facilitate the discussion, assisting campers in finding music/science connections by asking leading questions. However, this often proves to not be necessary.

A Few Specific Examples

Andrew Fraknoi's excellent article “[The Music of the Spheres in Education: Using Astronomically Inspired Music](#)” in *Astronomy Education Review* includes a large compilation of music based on astronomical phenomena. In the spirit of Fraknoi's list, I'll describe several compositions I've found effective in demonstrating intersections between music and astronomy.

On the Camp's opening night, the traditional music selection is “Music of the Night” from Andrew Lloyd Webber's *Phantom of the Opera*. The piece contains dramatic lyrics, making it an ideal first-

night selection. The text, “Let your mind start a journey through a strange new world,” which occurs at the song’s central climax, is particularly fitting for the beginning of Camp. This text sets the stage for the adventure that is Astronomy Camp, an adventure in which students will be encouraged to shift their perspectives about the world around them. I often begin “Music of the Night” with the telescope dome closed, and start opening the dome at the onset of the central climax — a particularly dramatic and inspiring effect. “Music of the Night” is an Astronomy Camp theme song of sorts, and the “Let your mind start a journey through a strange new world” text was featured on the 2001 Camp T-shirt.

On the second night I frequently present the finale of *Transit*, a work for electric guitar and computer-synthesized orchestra by University of South Carolina composer John Fitz Rogers. *Transit* is a large-scale work that combines rock and classical elements and causes students to think broadly about relationships between music, science, and technology. The solo electric guitar line pushes both instrument and player to their limits. In the computer-synthesized part, there are rhythms so mathematically complex, and speeds so extreme, as to be completely out of the grasp of a human player. Thus, while the work’s title suggests the astronomical event characterized by one celestial object passing in front of another, in actuality the work can be seen as an example of creative interaction between humans and computers.

As the week progresses, I introduce the campers to music for the organ. The pipe organ is a superb instrument for “astronomical” music because of its wide dynamic range. The pipe organ can be alternatively very soft or very loud, is capable of producing a huge array of sounds, and can sustain notes indefinitely — excellent characteristics for music with an astronomical inspiration.

One organ work that makes a frequent appearance is *Nova* by American composer, organist, and amateur astronomer Myron Roberts. *Nova* is a musical evocation of a Type II supernova. The beginning of *Nova* brings to mind the increasing instability of a star that is about to go supernova. Then, a lengthy crescendo builds to a series of massive chords (played on the full power of the organ) depicting the supernova itself. *Nova* concludes with a mysterious passage in which the organ’s highest and lowest notes are superimposed, evoking the supernova remnant’s dispersal into space.

Live Performances at Camp

At the 2011 Camps, we extended the music component to include a live session at the organ. This event featured my performance of my own composition *Nebulae*, a musical journey through the process of star formation. *Nebulae* opens with a mysterious, ethereal section depicting the beginning stage of star formation: a dark, cold molecular cloud. A violent passage suddenly ensues, evoking the arrival of a supernova shock front — one possible mechanism for triggering the collapse of the cloud and the start of star formation. A central dance section that grows in both intensity and rhythmic complexity marks the protostar stage. This dance builds to a series of large chords played on the full power of the organ, signaling the start of nuclear fusion and the birth of a star. *Nebulae* concludes with a fast-moving passage evoking the brilliance of the newly formed star.

For this live performance, I used the technique described earlier, in which I do not highlight specific astronomy/music connections. Before my performance, I conducted an introductory activity summarizing the stages of star formation. This activity involved students sequencing a set of images representing various stages of the star-formation process. I then performed *Nebulae*; during my

Some Other Musical Selections

In addition to *Nova*, two other examples of organ pieces with astronomy connections are *Coalescence* and *Time Machine* by University of Houston organist/composer Robert Bates. These two works combine a live organ part with a pre-recorded segment in which the organ’s sound has been manipulated via computer. *Coalescence* is an evocation of the origin of life on Earth and can serve as a departure point for discussions of early Earth history, the early solar system, and even astrobiology. *Time Machine* is a musical depiction of a journey through a wormhole.

Other works include (University of South Carolina) Reginald Bain’s *degrees of accuracy* for trombone and computer-generated sounds — a piece based on the number pi. The main theme is constructed by mapping digits of pi onto musical notes, and many of the rhythmic relationships are based on pi as well — a fascinating example of creative relationships between mathematics and music.

Movements from George Crumb’s *Makrokosmos* series have made appearances, as has “Jupiter” from British composer Gustav Holst’s *The Planets*. From an educational standpoint, “Jupiter” provides a springboard for introducing students to important British astronomers such as William Herschel. Herschel is often referred to as the father of modern astronomy, but he was a musician — organist, conductor, and composer — for much of his career.

Another work with a historical/cultural basis is Australian composer Ross Edwards’ *Symphony No. 4: Star Chant*, a large-scale piece for chorus and symphony orchestra. *Star Chant* features a choral text which pairs Western star and constellation names with their Australian aboriginal counterparts. I use *Star Chant* to introduce students to the fields of cultural astronomy and ethnoastronomy.

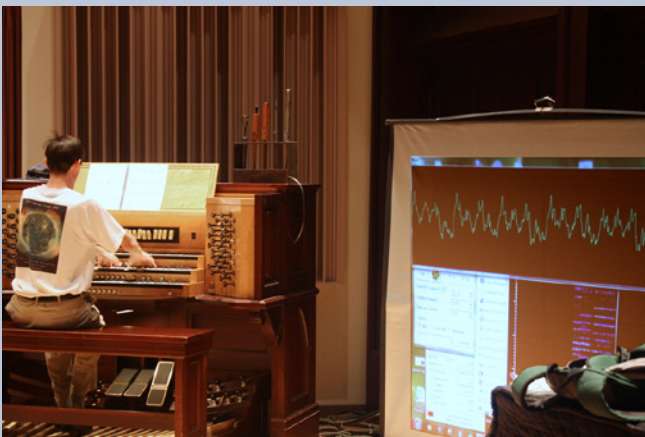
— M.W.



I'm leading the 2011 Beginning Teen Astronomy Camp participants in an introductory activity illustrating the process of star formation. (That's me at far right.) In this activity, campers sequence images representing key stages in the star formation process.



Following the introductory activity, I perform my organ work *Nebulae*, a musical journey through the star formation process, for camp participants.



As I perform *Nebulae*, the output from a computer sound spectrum analysis program is projected (right side of the image), giving camp participants a visual representation of the complexity of the organ's sound.



After the conclusion of my performance, counselor Jeff Register (center) uses a Slinky to lead camp participants in an experiment investigating the properties of sound.

Kate Brutlag Follette (The University of Arizona) x 4

performance the output of a laptop-based sound spectrum analysis program was projected onto a large screen.

After listening to *Nebulae*, the students discussed the ways in which the music they just heard connected with the astronomical concepts introduced in the opening activity. As expected, the students were able to make and express cogent connections between music and astronomy — no doubt assisted by the “wow factor” of a live performance on a large pipe organ. Student reactions to *Nebulae* tended to be particularly insightful. For instance, I had students make connections between the superimposition of very high and very low organ sounds and hydrostatic equilibrium in a star.

Our event at the organ also included a hands-on discussion on the physics of sound. I had a set of small organ pipes available, so students were able to get a close-up look at the sound source of a pipe organ. We used our laptop-based analysis program to display the sound spectrum of various notes from the organ. The myriad sounds and tone colors produced by the organ differ both in the actual overtones present and in the amplitudes (volume levels) of those overtones. Also, when the organ is played at full volume, the overtone structure produced is extraordinarily complex because many pipes are sounding at the same time — even when only one key is pressed. The organ is thus a wonderful vehicle for exploring how overtone

structure determines the nature of the sound produced.

Let Your Mind Start a Journey

Astronomy Camp is not just about developing students' knowledge of STEM fields. It is also about inspiring students, encouraging them to use their imaginations, and broadening their perspectives about the universe around them. The Camps take place in the aesthetically impressive environment of a mountaintop observatory, and the inspiring experience of observing with large telescopes under dark skies is a central feature of the program. Astronomy Camp is thus an ideal setting for creative educational activities that combine science and the arts.

Just imagine, once again, that you are in an observatory dome, with a large telescope looming over you in the dark. As you listen to the evening's music selection, you are inspired to “let your mind start a journey through a strange new world.” [\[RETURN\]](#)

MATTHEW WHITEHOUSE is an organist, composer, and astronomy educator. He is on the public outreach staff of Kitt Peak National Observatory and serves as music director at Christ the King Episcopal Church in Tucson. Sound files of his compositions can be found on his [website](#).