Enhanced Public Outreach With Asteroseismology

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Asteroseismology, the study of stellar oscillations, is allowing us new ways of determining the inner workings of stars, revealing information regarding their evolution, chemistry, thermodynamics, and more. By scaling the frequencies of these oscillations appropriately, they can be brought within the audible range of the human ear, producing "music" from the stars. From here, these sounds may be used as source material for musical composition or, when presented in a group of several stars, may be used as a means of demonstrating differences in physical characteristics of different groups of stars. This paper reports current work on a project funded by the NASA Space Science Student Ambassador program that aims to present asteroseismology as public outreach.

Introduction

Zoltán Kolláth has elaborated[1] on the value of relating stellar vibrations to music in addressing the general public. In his paper (1), he states:

> Parallels between science and art have always helped in expressing new scientific ideas to non scientists…Pulsating stars provide a novel parallel between astrophysics and musical acoustics.

Kolláth and Jenõ Keuler have done similar work in terms of composition via their "Music of the Spheres" project (http://konkoly.hu/stellarmusic/). It is continuing with this vision, that the project presented here allows the public to experience the science of asteroseismology firsthand.

The first facet of this project is to construct a publicly accessible interactive computer installation where a user may discover the differences in stellar characteristics relating to the oscillations they produce. This presents a unique opportunity to present various means of stellar classification (spectral type, classification by pulsator type, stages of evolution, etc.) allowing the user to "hear" the differences. From here, he/she will have the opportunity to create star systems of their own by adding vibrations of various stars to one another, creating a personalized "stellar symphony". In much the same way that the proliferation of breath-taking Hubble Space Telescope images has captured the imagination of people everywhere, this other dimension of perception, stands ready to fill the public with wonder.

In addition to the interactive installation element, I plan to produce an original piece of music that utilizes stellar pulsation as inspiration and musical content. The profound ways humans connect to sound, particularly music, reflect the entire spectrum of emotion and the human condition. I feel it is a natural extension that people find that connection also as a source of knowledge. For this reason, many people who would ordinarily not pursue such scientific matters can be reached through the power of music. As a consequence, this will provide the groundwork for composers and artists to use stellar vibrations in their own creative works. The Rauch Planetarium in Louisville, KY, has agreed to provide the venue for the debut of the composition and to temporarily house the aforementioned installation.

The current stage of the project stands at the phase of compilation of data and transforming them into audible sounds. As the central element to the endeavor at large, the process being used to generate and manipulate these sounds is detailed here.

From Observation to Audible

Collection of asteroseismological data presents several special considerations (thus complications) that arise from the especially long periods of the oscillations observed. Since the component frequencies resolved through Fourier analysis models are typically on the order of 5-100 $days^{-1}$, they lie well outside the audible range of human hearing. Expressed in units of s^{-1}, the frequencies are typically 60-3000 μHz. By scaling these by a factor of 10^6, the components are brought above the human hearing threshold of 20-40 Hz (This threshold varies greatly from person to person, but proves to be a sufficient standard.). The component frequencies for two vastly differing stars are shown below.

Nu Eridani		
Freq (1/day)	Freq (Hz)	Freq (microHz)
5.76326	6.67044E-05	66.70439815
5.65391	6.54388E-05	65.43877315
5.62009	6.50473E-05	65.04733796
5.63715	6.52448E-05	65.24479167
7.89757	9.14071E-05	91.40706019
6.24352	7.2263E-05	72.26296296
6.26181	7.24747E-05	72.47465278
7.20012	8.33347E-05	83.33472222
0.43235	5.00405E-06	5.004050926

Table 1: Component Frequencies for Nu Eridani[2]

GD358	
Freq (Hz)	Freq (microHz)
0.001296599	1296.599
0.0012554	1255.4
0.001420095	1420.095
0.002593208	2593.208
0.002675487	2675.487
0.002366266	2366.266
0.002359119	2359.119
0.002154021	2154.021
0.001378806	1378.806

Table 2: Component Frequencies for GD358[3]

The method used by Kolláth and Keuler in their collaboration mentioned above primarily uses additive synthesis techniques through a software package entitled Csound. For the project discussed here, I am using a platform called Max/MSP which is a fully-integrated object-oriented programming platform, but contains the advantages of visual interface as well as straight-forward connectivity to external midi-controllers for expanded real-time control over the sounds produced. The following image shows one such additive synthesis object created within Max/MSP that represents one "star". Each component frequency is mapped to a simple sine-wave oscillator with an automated volume control.

Of course, a series of frequencies alone does not represent a musical object. The temporal variation in the contribution of each component frequency may be modified using the "function" windows depicted in the figure. The shape of the function represents the amplitude of each frequency over a time domain which may be changed by a simple input argument.

Future Work

With the groundwork now set to use the stellar vibrations as musical objects, the focus now turns to the development of the user interface for the installation such that the user will intuitively be able explore the differences in physical properties of stars through hearing the sense of sound.

References

[1]Kolláth, Zoltán. "Public Outreach in Asteroseismology." Astrophysics of Variable Stars. Astronomical Society of the Pacific Conference Series 349 (2006): 421.

[2]De Ridder et al. "Asteroseismology of the β Cephei star ν Eridani – III. Extended Frequency Analysis and Mode Identification." Mon. Not. R. Astron. Soc. **351,** 324Ð332 (2004)

[3] Kepler et al. "WET Observations fo GD358 in 2000." Baltic Astronomy. V.12 (2003) 45-53

Figure 1: Stellar Synthesis Object