

499.00 seconds
neutrino oscillations for 3< voices
suzie shrubb 2019

introduction

the title of this work is derived from the time it takes solar neutrinos produced in the nuclear furnace of our sun to travel to the earth: 499.00 seconds.¹

neutrinos² are subatomic particles described as part of the standard model of particle physics.³ there are three different flavours of neutrino that become progressively heavier in terms of mass/energy⁴. the particle with the smallest energy is the electron neutrino; the muon neutrino in the middle and the largest energy: the tau neutrino.

solar neutrinos⁵ are produced as a result of nuclear processes that take place at the core of stars. the star at the centre of our solar system, our sun, produces billions upon billions of neutrinos into space travelling at the speed of light.⁶

¹ The average distance of the Earth from the Sun is 149,597,870 km or 92,922,807 miles. Dividing this by the distance light travels in one second 299,792 km or 186,282 miles gives us our figure 499.00 seconds. Source for this data NASA.

² The name "neutrino" means "little neutral one", a term coined by Italian physicist Edoardo Amaldi.

³ Neutrinos belong to the wider group of elementary particles so far discovered and classified by the standard model that include the quark, electron, W and Z boson, photon, gluon and the Higgs boson.

⁴ Mass and energy are equivalent through the famous equation discovered by Albert Einstein: $E=mc^2$ (Energy is equal to the mass times the constant squared. The constant being the speed of light.)

⁵ unlike the photons from the sun that you shield from your eyes with sunglasses, that you feel warming your skin or ripening your strawberries, these ghostly particles rarely interact with matter. they are as invisible to you as you are to them and billions of these solar neutrinos stream right through you and everything around every second of every day, unfelt and unnoticed.

⁶ 186,287 miles per second or 299,792 kilometers per second.

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only one type of neutrino is produced by the sun: the electron neutrino.

a distinctive feature of neutrinos is that they can change or oscillate between these different flavours. so far, no other subatomic particle has ever been observed to do this.⁷

and, as these electron neutrinos travel from the sun to the earth they will oscillate or change between to different flavours of neutrino. at their detection on earth we find that some of the solar neutrinos have transformed into the muon and tau neutrinos.

it is as though the sun is singing at one specific note, which over the duration of 499 seconds constantly changes between three possible notes before settling on a chord made of these three pitches.

⁷ Indeed it was experiments on solar neutrinos that first discovered and verified this.

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performance directions

the piece can be sung by a minimum of three voices. i specify no maximum number of voices since this could be in the billions if we wanted it to be.

the energy/mass of each different type of neutrino has been directly related to specific notes or tones that preserve the relationships between these energies or masses.⁸

any tones may be chosen, however to preserve the note relationship to neutrino energy/mass ***the interval distance between the notes must be maintained.***

the piece is divided into three movements which run continuously and seamlessly into one another.

given timings are approximate guides. vocalists must allow themselves to follow their own intuitive senses and awareness of the inner sense and outer sound-scape when shaping the piece.

further directions are indicated in the notated parts of this score.

⁸ I have used data taken from The Standard Model of Particle Physics.

The Notes/Neutrinos

| | | |
|---|---|--|
| Electron Neutrino 2.2 eVc ² | Muon Neutrino 0.17 MeVc ² | Tau Neutrino 15.5 MeVc ² |
|---|---|--|

The image shows a musical staff with a treble clef. It is divided into three sections by vertical bar lines. The first section contains a single note on the first line of the staff. The second section contains a single note on the second line, with a double underline below it. The third section contains a single note on the second space, with a double underline below it.

The notes indicated here are suggestions.

Any notes may be chosen to suit the range of voices available.

Different pitches must conform to the interval relationships of the above notes.

Notes do not have to be exactly in tune with A4=440, G3=197.23, F3=174.61. We can allow for the subtle variations of the voice and brain in locating these notes.

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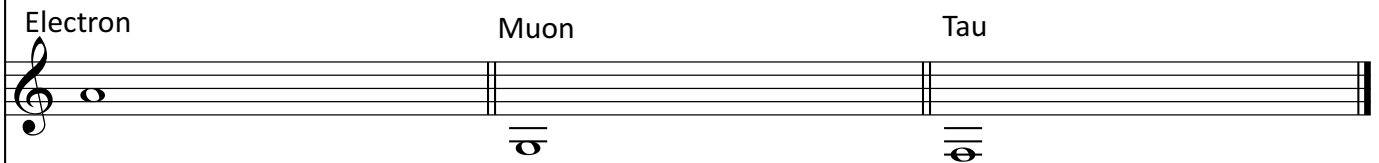
The piece is divided into three movements which run continuously and seamlessly into one another. Given timings are approximate guides.

First Movement- Beginning the piece 0 seconds -
The Electron Neutrino leaves the Sun



All vocalise the same pitch.
Dynamics and vowel/consonant sound is an open choice for performers.

Second Movement - 0-5 seconds onwards - 495 seconds
Neutrino Oscillation



Vocalists change at random between these pitches.
More than one vocalist can occupy the same pitch as another.
Vocalists do not have to change at the same time.
Vocalists must be guided by the balance between their inner sense of intuition and their outer awareness of the soundscape on when to change notes.
There is no specific duration for vocalists to remain on notes. As above vocalists must follow their own inner and outer awareness and intuition to choose whether to flit quickly between notes or remain on notes for longer periods of time.

Third Movement 495-499 seconds
Detection on Earth



Vocalists oscillating should start to settle by the end of the peice creating the final chord representing the state of three flavours of solar neutrinos detected on Earth.
At least a third of the vocalists should be singing notes representing Muon (G3) and Tau (F3) neutrinos.