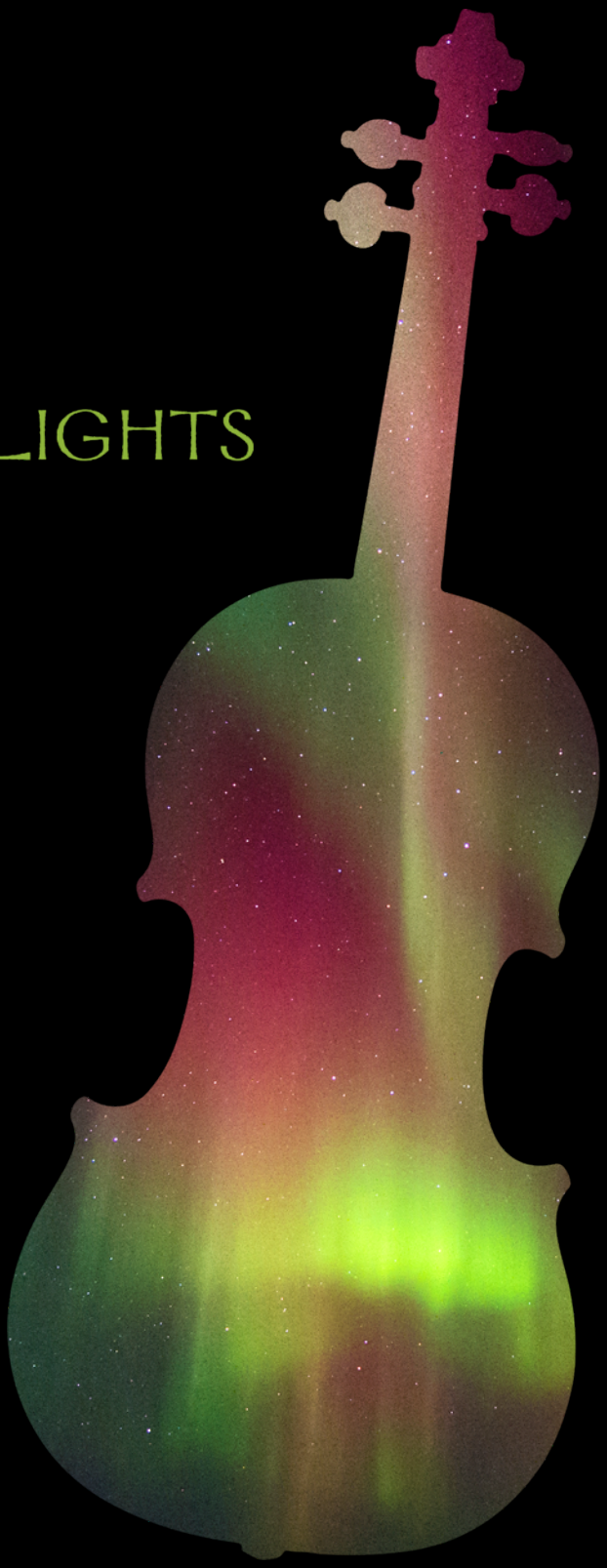
KV 265*
SCIENCE THROUGH ART

The Legend of
THE NORTHERN LIGHTS

KV 265 Teachers' Resource Guide



About KV 265's The Legend of the Northern Lights

Music by	Grammy-nominated composer, Christopher Theofanidis
Co-Commissioned by	KV 265 & Grant Park Music Festival
Film by	Emmy-nominated astronomer Dr. José Francisco Salgado
Script by	Kelli Landes and Anne Barlow
Inspired by a children's story by	Walt Terry
Premiered by	Grant Park Orchestra in association with the Canadian Space Agency

Taking as inspiration a Canadian children's story, *The Legend of the Northern Lights* is a fusion of science and fantasy that captures the imaginations of all ages, seamlessly combining music, film, narration, and animation. It recognizes both the cultural stories surrounding the aurora and the actual science that causes them.

The film takes the audience on a spectacular voyage from the Earth's upper atmosphere to the Sun, and to the far reaches of subarctic Canada. This multimedia work features NASA images of the Sun, NASA animations of coronal mass ejections (CMEs) interacting with the Earth's magnetic field, and the auroras from space as well as original time-lapse photography of this wondrous phenomenon shot on location, from Yellowknife, Northwest Territories, Canada.

About KV 265

KV 265 is a non-profit organization whose mission is the communication of science through art to communities worldwide. It seeks to heighten appreciation and understanding of art, music, science, and technology, and to inspire further exploration of these disciplines among its audience members through multimedia concerts, lectures, and educational workshops

Background

In 2000 Dr. José Francisco Salgado (then an astronomer at the Adler Planetarium in Chicago and an adjunct professor at Benedictine University) began to apply his skills in scientific illustration and photography to create astronomy-themed artwork that would "provoke curiosity and a sense of wonder about the Earth and the Universe". This evolved into a series of multidisciplinary projects where art is used as a vehicle to communicate science and to inspire people to learn about science on their own. The flagship project of this series has been the Science & Symphony films. This project began in 2006 as a collaboration with the Chicago Sinfonietta. It consists of live performances of classical music works accompanied by high-definition science films produced specifically for these works.

Formation of KV 265

Building on the overwhelming success of the first two films, Dr. Salgado, Anne Barlow, and Dr. Geza Gyuk, formed KV 265. This non-profit organization, whose mission is the communication of science through art, has taken up the mantle and continued to expand on these performance and educational experiences. Through partnerships with symphony orchestras, chamber musicians, composers, artists, scientists, and educational institutions, KV 265 presents multidisciplinary works connecting disciplines including astronomy, photography, music, film, and storytelling.

The Northern Lights, Scientific Perspective

These natural displays of light are technically known as *auroras*. When these occur in the Northern Hemisphere, they are called the *aurora borealis* or Northern Lights, and when they occur in the Southern Hemisphere, they are called the *aurora australis* or Southern Lights. Because of the way landmasses (and therefore human populations) are distributed on Earth, *auroras* are more easily visible in the Northern Hemisphere than in the South, which is why we hear less about the Southern Lights.

Auroras occur high up in the atmosphere where the air is more than a million times thinner than here on the ground. At about 90-160 km up they are far higher than the highest airplanes but below where satellites such as the International Space Station orbit. Their great height allows auroras to be seen from distances of hundreds of kilometers.

Auroras have their origins, not on Earth, but on the Sun, which is the star around which the Earth orbits. The fiercely hot outer layer of the Sun, the corona, emits a steady stream of particles that are high in energy called the solar wind. These particles flow out from the Sun and a small fraction encounter the Earth. Luckily for us, these particles carry an electrical charge and are affected by magnetic fields so they are mostly blocked or trapped by the Earth's magnetic field. The trapped particles form the Van Allen radiation belts that are very dangerous for manned space flight.

However sometimes the Sun ejects a very large number of particles (electrons and protons) at the same time. Such an event is called a coronal mass ejection or CME. Although the ejected particles travel at very high speeds, the distances in the solar system are so vast that it takes two or three days for the "storm" of particles to make the journey from the Sun to the Earth.

On arriving at Earth, the storm of high-energy particles, shake the Earth's magnetic field violently, freeing some of the trapped particles. Because of the way the Earth's magnetic field bends into the Earth's surface at the poles, and because the Sun's particles carry an electrical charge that is affected by magnetism, the swarm of particles is guided by the Earth's magnetic field and directed toward the north and south magnetic poles. This is why we see the auroras most strongly near the poles, although sometimes they can be seen quite a lot farther south.

These "freed" particles smash into atoms and molecules in the Earth's upper atmosphere. Our atmosphere is mostly made up of nitrogen and oxygen gas. When the incoming particles collide with the atmospheric gas particles, the latter emit particles of light called photons. Each type of atom or molecule emits a characteristic set of colors under such circumstances, which is why the auroras have the colors they do. Green, red, and purple are the most common colors. There is a slow "leakage" of energetic particles from the magnetic field that causes auroras on most clear nights. But the CME storms produce magnificent displays that cover the polar skies with light and even produce aurora that can be seen as far south as Texas!

The Northern Lights, The Children's Story

The script for this production of *The Legend of the Northern Lights* was inspired by a story written by Canadian author Walt Terry. During WWII, Mr. Terry was a navigator on Lancaster Bombers for the Canadian Air Force. On one mission, he was badly wounded, and had to have major surgery. Following that, he was shipped to a safe location in Labrador Canada to recover from his wounds and surgery.

It was there that he first got to know Canadian native peoples, and learned from them some of their customs and traditions. Some years later, he wrote a series of short stories and poems for the children of close friends, and *The Legend of the Northern Lights* was among them. He wove some of what he learned about the auroras from the natives into the original story that became the inspiration for this production. Although inspired by the children's story, this version of *The Legend of the Northern Lights* has been altered with the addition of new characters, film, and music and to fit the scientific aspects of the production.

The Story and Music

The film opens with a splash of musical color as the camera orbits around Earth. We can see the city lights that flow past our point of view and some lightning from storms in the clouds. The music features a pulsing theme. This theme fades, and is replaced by arpeggios – musical chords in which the notes are played in sequence rather than all at the same time. These are played on the strings and harp. We then see the opening credits. During the opening credits, a number of the recurring musical themes are presented, that later are developed into *leitmotivs* for various aspects of the film. We again see the rotating Earth, and the city lights.

We then see a series of questions flashing on the screen, while the child actor asks these questions. The last question is, "What are the Northern Lights?" This question sets up what is to come next. In the music, we hear the Northern Lights leitmotiv. The adult actor then takes up the question, and in dialogue with the child, gives a scientific explanation (while an animation plays), and explores various other cultural explanations with accompanying images. The Northern Lights leitmotiv is musically developed, and the adult actor shows the child an old box that has come down to him from his ancestors. It contains a family —that they have their own legend about how the Northern Lights come to be.

To a background of mysterious music, the narrator explains that something happened to his great-great grandparents Archie and Nunataq, and they swore that it was true, and that old, beaten, dark case he shows the child is proof of the story. The scene moves to the far north and a lonely cabin in the woods.

Suddenly, the narrator then shifts our attention to the Sun, and we see visuals of our star with powerful energies being manifested by the roiling surface and loops of mass dancing on the surface. The music changes to powerful chords in the brass, punctuated by the percussion, musically demonstrating the power of the Sun. We see storms flash across the surface and, as the Northern Lights theme returns, an ejection of matter from the Sun's surface. Other such ejections follow.

The scene then changes to a view of the Earth, far in the distance, and we travel towards it with the coronal mass ejection (CME) particles. We can see the particles hit the Earth's magnetic field, and the film dissolves into as scene of pine trees in the northern winter.

We travel down to ground level, with musical hints of both the Sun and Northern Lights accompanying us. We pass an alpine stream, see some wildlife and a beautiful, frozen landscape. The music here is mostly strings, harps, and some percussion. A mysterious hooded figure is seen crossing the screen. The narrator resumes his story, and we see a trapper traveling the landscape via dogsled. This is Archie, returning home from a trip.

To a scampering pizzicato theme in the strings, accompanied by woodwinds and harp, we travel through the snow with the sled. It is moonrise when Archie arrives at his cabin. The dogs settle in for the night, and Archie greets his wife, Nunataq. They settle in for a peaceful night.

We see the interior of the cabin, and the fire on the hearth. Suddenly, there is a knock at the door. A knocking theme is heard in the music. To ominous music, Archie opens the cabin door and looks to see who is there. We hear the mysterious stranger theme, and see, through the cabin window, a hooded figure, dressed all in black. The stranger enters the cabin and joins them by the fire. In the music, we hear echoes of the Northern Lights theme and the mysterious stranger music. The stranger lays a dark case on a table. We see the case open slightly, and both light and music seem to leak out of the case.

Nunatak offers the stranger tea and bannock biscuits. After hungrily eating his biscuits, the stranger thanks them, in a kind of rippling song, accompanied by the orchestra. He offers them a gift in return for the food — a gift of music. The stranger takes a violin from the old case. He goes out into the snowy night, and as he begins to play, the bow begins to emit ribbons of light. Musically, the Northern Lights become a violin solo with orchestra. As the images of the Northern Lights (actual images, not animations) become more complex and glorious, so does the music, mingling the Sun theme, the Northern Lights theme, and the other musical themes presented in the story.

In the film, from this point onward, we leave the family story and see a parade of images of the Northern Lights as they actually appear in Yellowknife, Canada. We see globes and curtains of plasma green, yellows, and purples, dancing and swirling in the atmosphere as pressure changes in the air cause them to move and change.

We have moved from the story now to the science. We see the Northern lights over frozen lakes, mountains, forests, and cabins. Then the Sun theme is heard again and we move to an animation of the Earth's magnetic lines, and we see the solar particles being funneled around the North Magnetic Pole. We see images from the International Space Station (ISS) showing the Northern Lights with the Canadarm manipulator arm visible. More film follows, showing the flow of the Northern Lights across the top of the Earth. The orchestra joins in with the Northern Lights theme, the Sun theme, and others. The orchestration becomes more complex and reaches a climax as we see the Earth rotating, ablaze with the Northern Lights.

The Legend of the Northern Lights, The Music

Writing music for a film is very different that writing a song or a work for orchestra. The musical ideas have to relate to what's on screen, and the composer is not in charge of what ideas appear when. This is very different from writing a symphonic composition, where the composer is in complete charge of the musical score.

In this case, composer Christopher Theofanidis had to create musical ideas (themes or *leitmotivs*) representing the characters and supporting the narrated sections of the story as well as the scientific images. The creative team first worked to develop a storyboard of the various scenes and then adjusted the script, film, and music to create the final project.

Program Notes by Composer Christopher Theofanidis

KV 265's admirable goal of fusing science with the arts appeals to me very deeply, as I have always thought that the deepest aspirations of humanity can be found in both disciplines. In this particular case, the vehicle for bringing these two things together is a simple children's story told with narration, music, and film, and it is one that tries to underscore the idea that the journey of evolving is driven by our basic need to both admire and to technically understand something.

The actual story begins with a child looking into the night sky and asking questions of a grandparent: 'how many stars are there?', 'how old is the moon?', and the like. The final question, 'what are the northern lights,' starts the grandparent ruminating on how since the beginning of time, humankind has tried to answer these kind of questions —to explain what seems inexplicable— and has come up with answers reflecting the values of the time and the individuals searching for explanations. The grandparent explains that even in their own family there was a legend of the Northern Lights, and the rest of the story proceeds narratively from there.

It has been exhilarating to work with both the storytelling and filmic components of this work. The music tries to respond to both of these elements in a synthesized way —allowing moments of one or the other to dominate depending on the arc of the drama, as opera does between language, drama, and music.

Instrumentation

1 Narrator
1 Child Actor
Film
1 Piccolo
2 Flutes
2 Oboes
1 English horn
3 B-flat Clarinets (2nd doubles e-flat, 3rd doubles bass)
2 Bassoons
1 Contrabassoon
4 Horns
3 C-Trumpets
3 Trombones (3rd is bass)
1 Tuba
1 Timpani
2 Percussion
1 Harp
Strings

Science Glossary

atom	Atoms consist of a nucleus (plural nuclei) containing protons (positively charged particles) and neutrons (neutral particles). Around the nuclei are negatively charged particles called electrons.
corona	The corona is the gaseous outer layer of the Sun and other stars.
coronal mass ejection (CME)	A coronal mass ejection occurs when particles (mass) are ejected in large quantities from the corona of a star.
electrons	A subatomic particle with a negative electrical charge found in all atoms and acting as the primary carrier of electricity.
element	An element is the smallest particle of matter that has the characteristic properties of that kind of matter. Atoms of a particular element have a characteristic number of protons in their nuclei.
matter	Matter is anything that has mass and occupies space.
molecule	A molecule is the smallest particle of an element or compound that has the characteristic properties of that type substance. Usually, molecules have two or more atoms joined together, and are stable, not breaking apart easily.
particle	In chemistry, we use the word particle to mean any small bit of matter. We often use particle when we don't want to be specific as to the kind of matter involved.
photon	Light can exhibit properties of both a wave and a particle at the same time. When we look at the particle aspect of light, we call these particles photons.
plasma	Under some high-energy conditions, the electrons of the atoms are stripped from their nuclei, and the nuclei and electrons exist in a kind gaseous fluid called a plasma. Often under these conditions, the electrons can emit photons (particles) of light.
magnetism	Magnetism is produced by moving electrical charges (moving electrons). For this reason, electrically charged particles can affect magnets, and magnets can affect electrically charged particles.

Music Glossary

arpeggio	An arpeggio is a musical chord, but with the notes played in sequence, one after another, instead of together at once, as in a regular chord.
chord	In music, a chord is a group of notes of different pitches that are played together at the same time.
leitmotiv	A leitmotiv is a theme or melodic fragment that is used by a composer to identify a character or idea in a musical composition. It's a little like tagging an image with a name, but it this case it is a musical tag.
musical development	A theme or leitmotiv is musically developed by creating variations of it. These variations can achieved by changing the instruments playing them, by changing the harmonies, by slightly altering the melody or its rhythm, by inverting the melody (playing it upside down), and by other means.
pitch	Musical pitch is what we perceive when we hear a note as high or low.
pizzicato	Normal orchestral string instruments (violins, violas, cellos and bass) are played with bows. However they can be plucked with the fingers, and when this is done, it is called pizzicato.
theme	In music, a theme is a melody or fragment of melody.
string section	In an orchestra, the string section consists of the violins, violas, cellos and double-bass instruments. Usually, these instruments are played using a bow.
harp	The harp is a musical instrument consisting of a large wood and metal frame, with an array of strings of different lengths strung on it. The harp is played by plucking on the strings.
percussion instruments	Percussion instruments are musical instruments played by hitting, shaking or rubbing (friction.) They can be made of wood, metal or other substances (plastic being common in modern times.) Drums, cymbals, gongs, bells and other percussion instruments are common.
brass instruments	Brass instruments are musical instruments made of thin, hollow tubes of brass and bent into a shape that makes them convenient to play. They are played by buzzing the lips into a cup-shaped mouthpiece.
woodwind instruments	Woodwind instruments are instruments that were traditionally made of wood and played by blowing into them. Some woodwind instruments are played just by blowing (as with the flute), but others have a thin wooden bit of reed attached to the mouthpiece to help make the sound. Today, some woodwind instruments are made of metal, as is the case for the flute.

For Further Exploration

Canadian Space Agency: AuroraMAX http://www.asc-csa.gc.ca/eng/astronomy/auroramax/

One of the best places in the world to view the Northern Lights is in Canada's Northwest Territories. The Canadian Space Agency has an aurora research program called AuroraMAX. When the Northern Lights are active, the AuroraMax cameras are turned on, and students and teachers can view the Northern Lights live over the internet. Replays of previous Northern Light events are also available on this website.

NASA Aurora Page http://www.nasa.gov/mission_pages/sunearth/aurora-news-stories/index.html
NASA Aurora Poster and PDF Document http://pwg.gsfc.nasa.gov/polar/EPO/auroral_poster/aurora_all.pdf
NASA Educational Resources for Teachers http://www.nasa.gov/audience/foreducators/index.html
NASA Educational Resources for Students: http://www.nasa.gov/audience/forstudents/index.html
NASA Scientific Visualizations & Animations http://svs.gsfc.nasa.gov
NASA Solar Dynamics Observatory http://sdo.gsfc.nasa.gov

DP Review: Auroral photography Guide https://www.dpreview.com/articles/8217618174/
Exploratorium aurora web resources: http://www.exploratorium.edu/auroras/
Library of Congress: Fun Aurora Facts http://www.loc.gov/rr/scitech/mysteries/northernlights.html
National Geographic: Aurora http://nationalgeographic.org/encyclopedia/aurora/
Salgado, José Francisco: Aurora Photography https://www.flickr.com/photos/josefranciscosalgado/albums/72157647463157014
Space Weather Forecast http://spaceweather.com
Stern, **David**: Secrets of the Polar Aurora http://www.phy6.org/Education/wstern.html

