EMILY COATES

Script for “A History of Light”

By Emily Coates

NOTE: “A History of Light” is a multimedia performance project created by Emily Coates & Josiah McElheny that premiered at Danspace Project/St. Mark’s Church in November 2018. (Scroll down to the end for the complete production credits.) The project is part 1 of a longer work.

INTRODUCTION

EC: I have a question.

What is the history of light?

Sarah plays the narrator. I play the dancer. Josiah plays our stagehand.

(EC off)

SD: I should quickly tell you that “photon” is the name for the particle that carries light.

And it is because of the humble photon that scientists are able to peer back in time—because light equals time equals history.

We can study the entire electromagnetic spectrum of light, which includes invisible light, such as x-rays and gamma rays. And we can detect light that is billions of years old.

And yet scientists have no way of accessing a history *before* there was light.

ACT I

Here we are, at the turn of the 20th century, in the panelled offices of the Harvard College Observatory, with Henrietta Swan Leavitt, who is studying light.

Leavitt hovers over her light lectern, holding a tiny metal tool above a photographed star the size of the period that punctuates this sentence. She is measuring the star's luminosity.

Leavitt was a "human computer," one among a group of women who carefully studied photographic plates of the night sky, which had been amassed by the Observatory.

Leavitt analyzed their contents, cataloguing vast swaths of the heavens—the Orion Nebula, the Magellanic Clouds (MA-JE-LAN-NIC).

She searched for variable stars, stars that fluctuate in brightness.

Through her meticulous research, she discovered nearly 2,000 of the must fluttering stars–the Cepheids (SEF-EE-IDS).

She also discovered a proportion, known as Leavitt's Law, which describes a direct relationship between the brightness of a star and its periodicity–the amount of time it takes a star to cycle through its fluctuations.

Leavitt's Law, gave astronomers a tool by which to measure the distances to the stars.

Suddenly, the Milky Way became local–our little neighborhood.

And the Universe suddenly became not four billion years, but FOURTEEN billion years old.

Henrietta, who was deaf for most of her adult life, was also plagued by illness. When she fell too sick to continue on, she wrote to her friends at the Observatory: "Send me some sky…"

MUSIC CUE: TRACK 1: HENRIETTA'S SOLO

[Henrietta's Solo]

MUSIC FADES OUT AS EC REACHES CARPET STAGE LEFT

(*After the solo*) SD: Astronomical scales of time and space are difficult to fathom… so we've created a physical illustration to help. Josiah, would you help us?

JM: Here is the earth.

Here are the satellites.

Here is the moon.

Here is the sun.

Here is the edge of the solar system.

Here, not much farther away is the edge of the Milky Way.

Here is some of the emptiness, perhaps the dark matter and energy that fill most of our world.

Here is the end of the nearby galaxies.

Now we are so far away that we are in the past, even as we stand on earth.

Here we are at the faintest earliest galaxies visible from our telescopes.

Finally we reach the edge and the beginning, the scattering of energy from the big bang itself. We have reached the beginning of light.

[TRANSITION: EC & JM sets up screen as *SD starts talking.]*

ACT II

SD: At the time of Leavitt's discoveries, the technology to record and replay a moving image was barely two decades old.

That technology helped to imprint another pioneering woman—the ballerina Vera Karalli–on celluloid film.

Karalli, one of the first Russian silent film stars, pioneered a physical language for cinema that emphasized action over histrionic emotional display.

"I began a new epoch" (EE-POCK), she has said of her work in dance and film.

Though Karalli played a range of characters that often bordered on stereotype, it is the subtle force of her gestures that remains.

Have we not too easily dismissed the power of the ballerina and her light—ness to redirect history?

Karalli's lightness was imprinted on celluloid film, and through light she is with us again.

START FILM 1 + MUSIC TRACK 2: Saint-Saens

[Dying Swan Solo plays, EC on Mat]

AFTER MUSIC FADES OUT — CUE FOR FILM 2: CHRYSANTHEMUM TO BEGIN

[Chrysanthemum plays, EC walks slowly through space, SD joins and begins to conduct, following the conductor on the screen]

[When that film ends, SD facing screen]:

SD: Why are the ballerinas always *dying?*

FILM 3: DYING SWAN FINALE BEGINS AS SARAH RETURNS TO HER SEAT.

Thankfully, technology lets us rewind—undoing pathways of light, and of history.

By running the film in reverse, we free Karalli, bringing her back to life.

[Dying Swan Final Scene in reverse plays out]

ACT III

SD: I wonder about gravity; I worry about the speed of light. When will Standard Model of physics fail? I'm a particle physicist, but we don't even really know what a particle is.

Scientists face more uncertainties than certainties. The answers we've figured out up to now are not enough, and certainly have not come from a diverse enough range of voices.

Do you recognize the name Jedidah Isler?

She was the first African American woman to graduate with a PhD in Astrophysics from Yale—**in 2015.**

2015?!!!!

Another master of light we should recognize is Carol Mullins–our lighting designer.

{*recognize Carol Mullins!*}

(*Carol gives a couple quick blinks of light*)

(*Light shifts*)

SD: Now for some galactic light…

It's 1971, and Alice Coltrane has just returned from her first pilgrimage to India. She records *World Galaxy* and *Universal Consciousness*, two albums that compositionally explode into a self-actualized Outer Space:

"Universal Consciousness literally means Cosmic Consciousness, Self-Realization, and illumination," Coltrane writes. This music involves "…a Totality concept, which embraces cosmic thought as an emblem of Universal Sound."

Through her voracious syntheses of Eastern spiritual influences and black avant-garde jazz aesthetics, Alice Coltrane proposed a universality that embraces plurality—'the paths are many but the destination one.'"

After her husband John's death, Alice began to invent galaxies. "Galaxy in Turiya" (TUR-EE-YA), "Galaxy in Satchi-danada" (SAT-CHI-DA-NA-DA), ("Galaxy around Oludumare" (O-LOO-DU-MA-RE), she titled her songs.

Alice Coltrane's imagined galaxies co-exist with the galaxies that Vera Rubin sees in the 1970s from a telescope in the mountains outside of Santiago, Chile.

Over the course of her twelve-hour shift, she stands for 90 minutes at a time, training her eyes on the night sky. She is studying the velocities of galaxies, in order to better understand the expansion of the universe.

Rubin's study of galaxies helped to flip the terms of astronomical research—from the seen to the unseen.

When scientists thought they were studying the Universe, they realized they were studying a mere 5% of the universe.

The scientific community has slowly embraced the study of "dark matter."

She never received a Nobel Prize.

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The contributions of women artists and scientists has been ignored and rendered invisible by the establishment for centuries.

And yet, women will never stop illuminating the Universe.

In Alice Coltrane's and Vera Rubin's galaxies, knowledge is created through tangible, specific, and visionary means. The spaces they created are marked by an urgent plea for cosmic connection.

Perhaps the traces of all of these women's lives are somewhere out there, traveling toward the Magellanic Clouds, as if light were the one form that could truly carry their genius.

CUE SOUND: VERA RUBIN TRACK as Sarah begins

[*EC: Rubin / Walking Mirror as Sarah reads Vera Rubin text]:*

SD: During the 1970s accurate rotation velocities in galaxies accrued rapidly, due principally to more sophisticated observing instrumentation and techniques, both in the optical and in the radio spectral regions. By 1975 there was an optical rotation curve for M31 that was flat beyond the nucleus and believable, with accurate optical velocities which extend to 120 arcminutes.

High resolution optical spectra across the nucleus still took 6 hours to obtain, even using a spectrograph which incorporated an image tube. The telescope operators at the 84-inch KPNO telescope would cringe when they saw us coming, for they knew it meant a long night of only 2 exposures, with the telescope operator sitting on the observing platform as required, with no job to perform after once setting the telescope at the start of the night. Telescope operators even covered the faintly luminous clock face, for we feared red light leaks in the spectrograph during the long exposures.

Brink's thesis, a high resolution study of HI velocities in the inner 60 arcminutes of M31, showed additional complexity: along many lines of sight a low velocity component coexists with the higher rotational velocity. While generally interpreted as outer disk gas warped back into the line-of-sight, and hence with only a small radial component of velocity, we should be aware that bars or other triaxial motions near nuclei may be responsible. As in M 31, ionized gas with low velocities coexists with the higher rotation velocities in many spirals I observe.

But lest you think that M31 was the first galaxy to define a flat rotation curve, let me refer you to the 1959 study of by Louise Volders, from HI observations made at Dwingeloo. For M33, HI velocities, as if drawn with a ruler, slice through a scatter of optical points. The lack of impact on the astronomical community is curious; perhaps the instrumental capabilities was doubted. Surely a falling rotation curve was expected, based on the rotation curve for our galaxy predicted by Oort's constants A and B and Oort was Volder's professor). By 1072 Rogstad and Skostak could assemble 5 flat HI velocity curves for Scd galaxies, obtained with the Owens Valley two-element interferometer. They conclude in their abstract:

"Because of the very flat rotation curves observed for these Scd galaxies, total masses extrapolated to infinite radius are not known. Surface must-luminosity ratios must reach values of =20 at the Holmberg radius…"

Before that decade was over, we all knew that rotation surveys for spiral galaxies are flat and the efforts to determine the distributions and amounts of the mass components are still underway. For every galaxy, we can determine only the lower limits of its mass, for a flat rotation curve implies that mass increases linearly with a distinctly untasteful circumstance in physics. Consequently, M/L increases with radius, as mass M continues to increase where optical luminosity L has already converged to its limiting value. Hence 21/cm studies of of spirals with large HI disks are especially valuable for inferring the distributions and amounts of dark matter at large radial distances.

EC ending USR, as she reaches behind the screen slides out of sculpture–CUE SOUND: ALICE COLTRANE "Oceanic Beloved", which will transform into SUN RA "Love in Outer Space"

[EC begins Balanchine phrase. @ a midpoint Sarah enters with Carried Mirror]

As EC crosses Downstage from SL to SR, CUE FILM: MAYA DEREN (remake)

Music fades out on its own. Film continues to End. JM lowers flap. SD turns out Sky Plate.

Fade to Black.

A History of Light

Premiere: Danspace Project/St. Mark's Church, November 8, 9, 10, 2018

Concept: **Emily Coates**

Conceptual Development and Dramaturgy: **Emily Coates and Josiah McElheny**

Choreography and Script: **Emily Coates**

Videos at the close of Acts II and III: **Emily Coates** and **Josiah McElheny**, in homage to Vera Karalli and Evgenii Bauer's *The Dying Swan* (1916), and Maya Deren's "The Very Eye of Night" (1958)

Unaltered video excerpts in Act II: *The Dying Swan*, directed by **Evgenii Bauer** (1916), and *Chrysanthemum*, directed by **Pyotr Chardynin** (1914)

Astronomical Sky Plates: courtesy of astrophysicist **David H. Weinberg**, Ohio State University and Sloan Digital Sky Survey, New Mexico

Sculpture in Act III: **Josiah McElheny**, "Walking Mirror I" (2012), wood, mirror, nylon webbing, metal hardware

Visual objects designed for Acts I and III: **Emily Coates**, **Josiah McElheny**

Music Direction and Composition: **Will Orzo**

Lighting Design: **Carol Mullins**

Video Editing: Yana **Birÿkova**

Technical direction: **Neil Mulligan**

Performed by: **Emily Coates, Sarah Demers, Josiah McElheny**

Musical Sources: Wolfgang Amadeus Mozart, "Sonata No. 8 in A minor, K 310" (1778); Camille Saint-Saëns, "Le Cygne" (1886); Alice Coltrane, "Oceanic Beloved" (1968); Sun Ra, "Love in Outer Space" (1975).

Text quotations from Alice Coltrane, Vera Karalli, Stéphane Mallarmé, Vera Rubin.

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Note from the collaborators

A History of Light is an ongoing research experiment in combining forms of cultural knowledge, from science to art, in order to find a new language with which to tell stories. Everything this piece is trying to do—and perhaps most of all—should be understood as a conversation across our diverse disciplines. Our dialogue is one that keeps growing and evolving over time. In sharing this piece with you, we hope to welcome you to this conversation. –EMILY COATES & JOSIAH MCELHENY