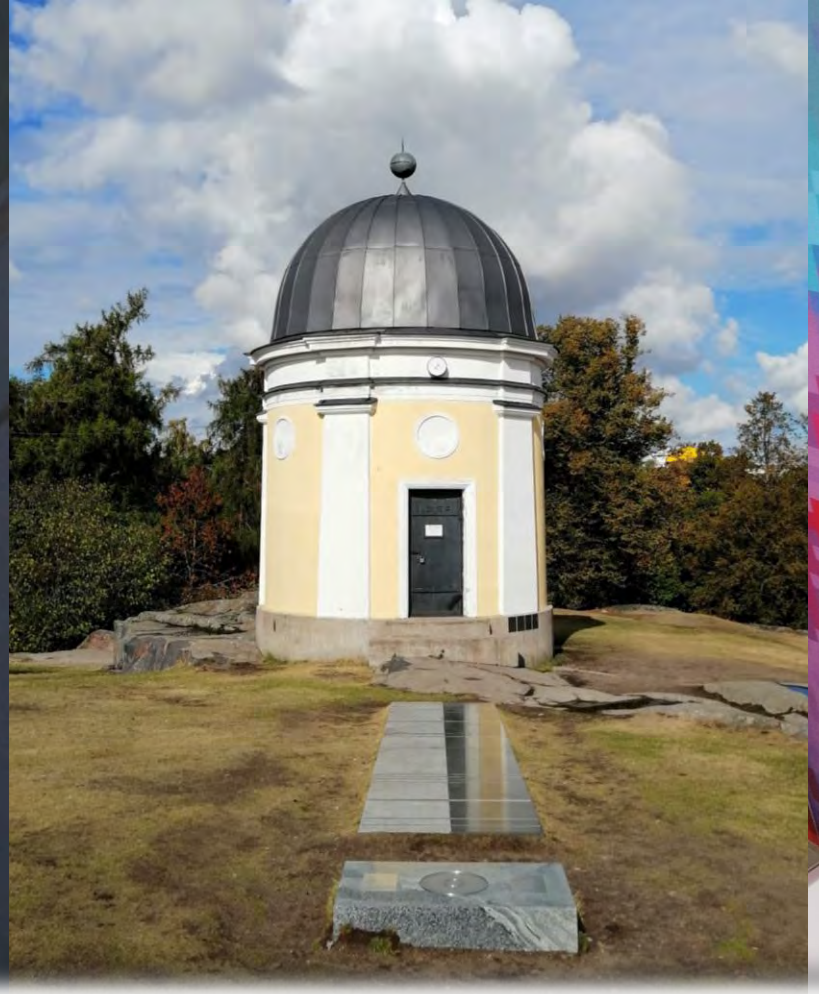


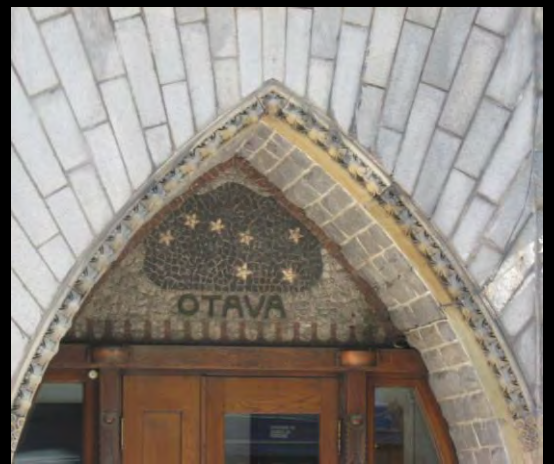
# Spectroscopy

in the public art of Helsinki
and in the history of science

Niklas Hietala



Examples of astronomical art in Helsinki



# *Alexander II*

A bronze statue in a prominent place at the Senate Square in central Helsinki

Revealed on 29 April 1894

Designed by Johannes Takanen and Walter Runeberg

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Lux symbolizes arts and science

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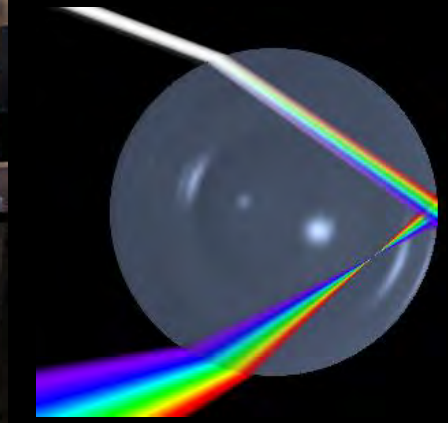
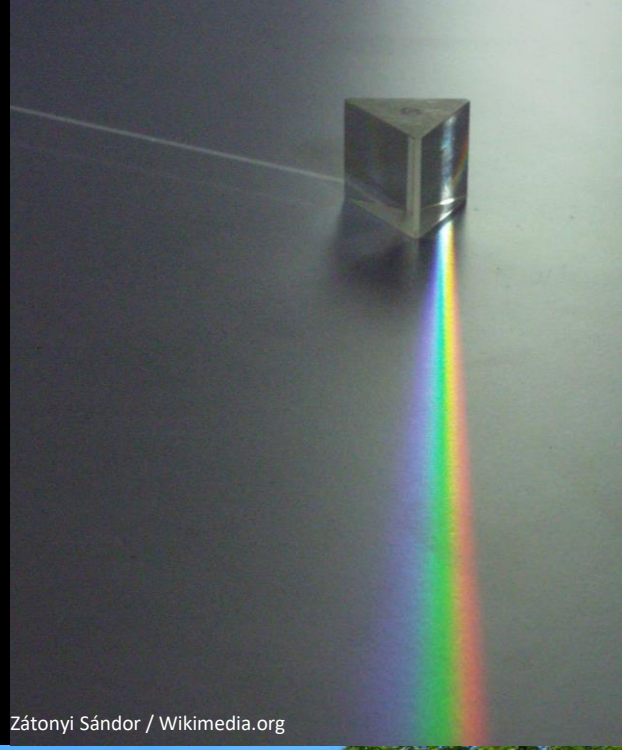
Lux symbolizes arts and science

The muse of science is holding a spectroscope!





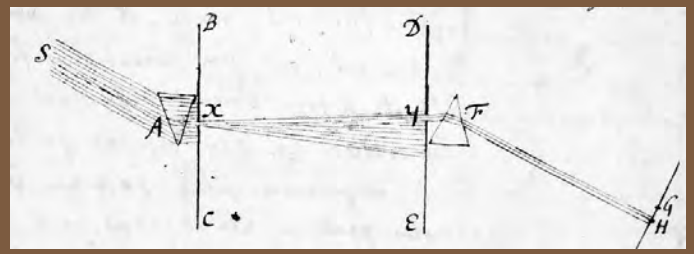
Zátonyi Sándor / Wikimedia.org

Rainbow in a mural of kindergarten museum in Helsinki

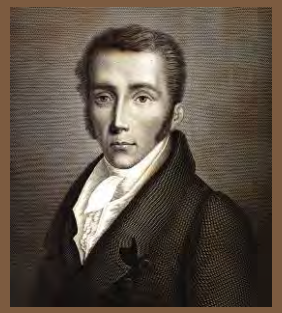
# Spectrum:
# The colors of rainbow

New children's hospital in Helsinki

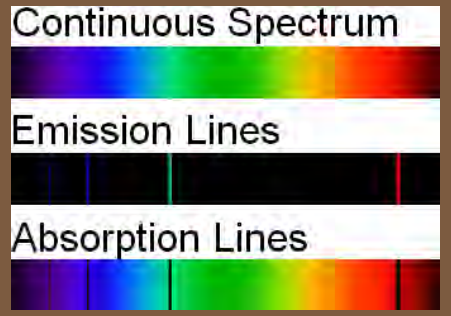
1665 Isaac Newton experiments with prisms



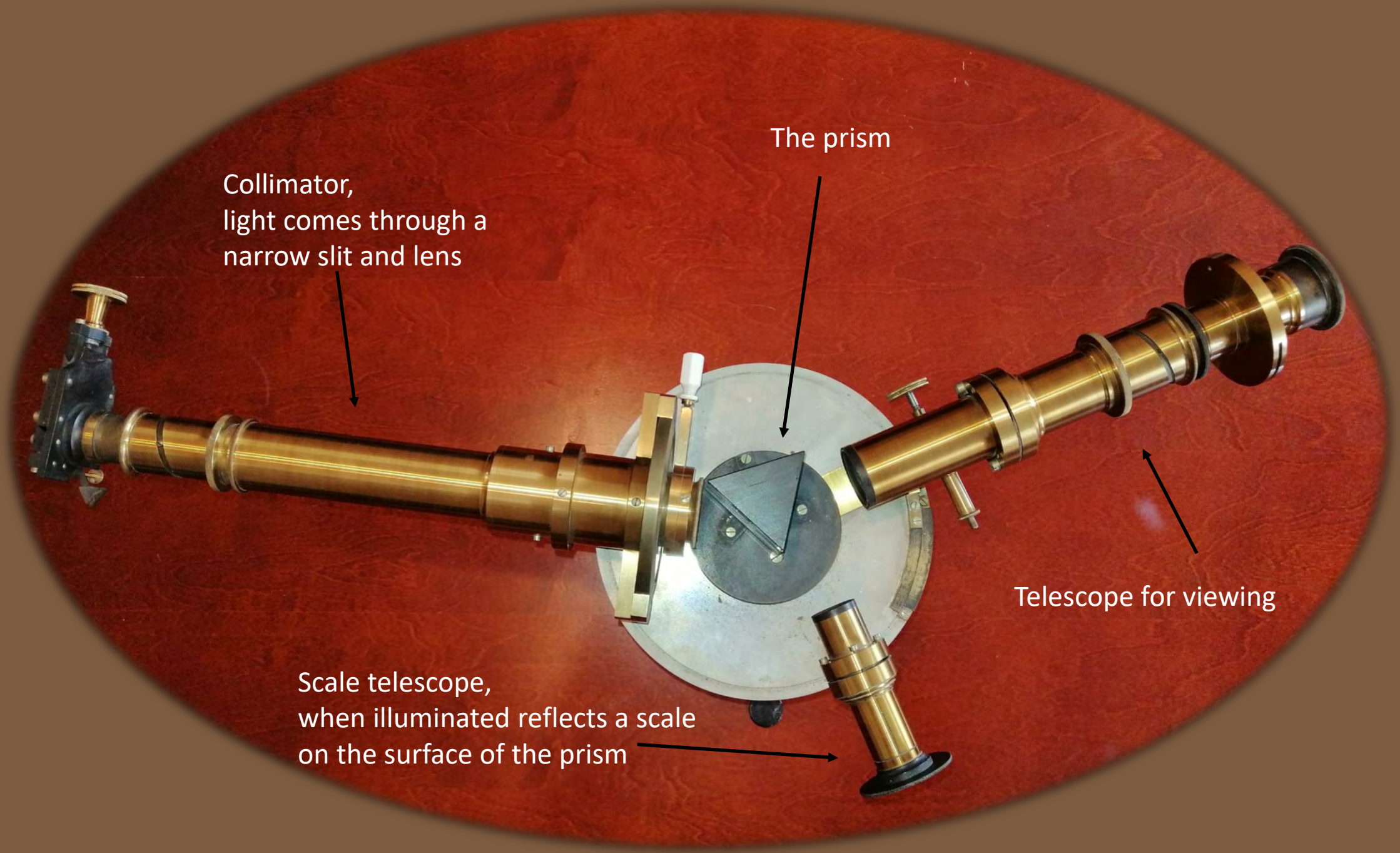

1814 Joseph von Fraunhofer studies sun light with a spectroscope




1860 Robert Bunsen and Gustav Kirchhoff study the spectra of the flames of burning substances




Spectroscope in the geological museum in Helsinki


The prism
Collimator,
light comes through a
narrow slit and lens
Telescope for viewing
Scale telescope,
when illuminated reflects a scale
on the surface of the prism

*Helios* (2010)
by Lauri Anttila

A sun dial  sculpture consisting of two pieces in front of the observatory of Ursa astronomical association

The smaller stone has a sun dial, which has no gnomon, but the time is seen from the reflection in the two metal rings

*Helios* (2010)
by Lauri Anttila

The larger stone depicts the Fraunhofer lines (the halves correspond to emission and absorption spectrum).

During the noon, a mirror on the observatory wall reflects the image of sun on the centerline of the stone.

*Helios* (2010)
by Lauri Anttila

The larger stone depicts the Fraunhofer lines (the halves correspond to emission and absorption spectrum).

During the noon, a mirror on the observatory wall reflects the image of sun on the centerline of the stone.

Also a calendar: on different time of the year, the image of the sun is in a different place along the length of the stone. Dates have been engraved in the stone.

# Lauri Anttila (1938-2022), conceptual artist, professor

- Has designed several sun dial sculptures


*Eratostheneen kaivo* (Well of Eratosthenes)
A sun dial where the deepest point of the shadow tells the time.

*Aurinkokello* (Sun dial)
There are four brown colored pillars with mirrors. Each of them reflects the sun to the aluminum pillars when it is a midday in a certain time zone (longitudes $0^{o}$E, $15^{o}$E, $30^{o}$E, or $45^{o}$E).

French philosopher Auguste Comte on stars:

We understand the possibility of determining their shapes, their distances, their sizes and their movements; whereas **we would never know how to study by any means their chemical composition**, or their mineralogical structure, and, even more so, the nature of any organized beings that might live on their surface

(Cours de Philosophie Positive, 1835)

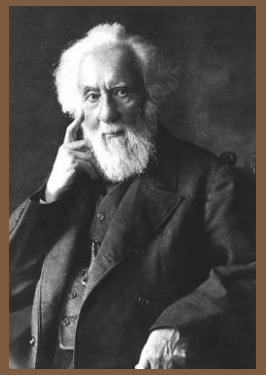
May Day celebration around Ursa observatory in 1970's
(Volker von Bonin, Finnish Heritage agency)

## Spectroscopy revolutionized chemistry

- Immediately, Bunsen and Kirchhoff found several new elements
  - Cesium (1860), rubidium (1861)
- Other scientist soon followed their lead
  - W. Crookes: thallium (1861), F. Reich & H. T. Richter: indium (1863), …
- Helium was first observed as a spectral line in the solar spectrum.
  - During the 1868 solar eclipse, Norman Lockyer studied sun's chromosphere (part of atmosphere)
  - Named after Helios, the Greek god of the sun

# Spectroscopy gives birth to astrophysics

1814 William Herschel studies spectra of stars (colors displayed in starlight)



William and Margaret Huggins

1864
- Spectrum of a planetary nebula
  - Distinction between nebulae (emission spectra) and galaxies (absorption spectra like stellar spectra)

1868
- Redshift of Sirius
  - radial velocity could be computed

1925 Cecilia Payne-Gaposchkin and chemical composition of stars
- Stars are composed primarily of hydrogen and helium

*Night sky* (2012)
by Terike Haapoja
in the façade of Myllypuro health center

The 950 LEDs visualize real-time magnetometer data from Northern Finland.

When there are northern lights in Kevo, Northern Finland, one can see green and turquoise waves in Myllypuro.

During low magnetic activity, the LEDs just visualize the fluctuating measurement data, as seen in the image.

*Spectrum* (2012)
by Terike Haapoja
in the lobby of Myllypuro health center

The four floors high painting portrays a sun burst.

Visualization of measurement data from Metsähovi Radio Observatory. One minute of data. Yellow areas are the solar radio burst in the frequency 300-400 MHz.

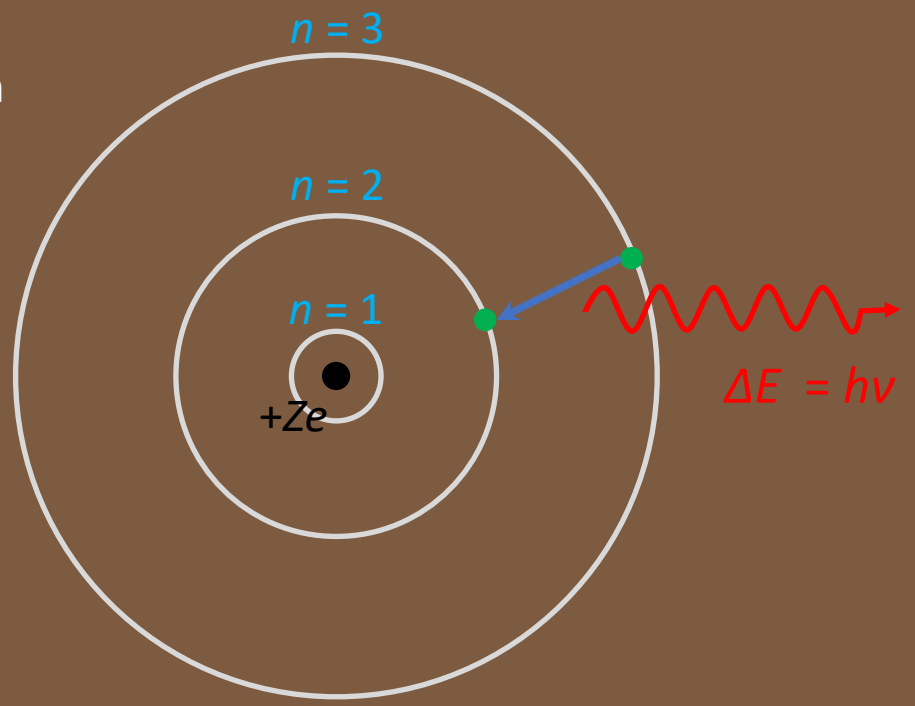
Jan Wagner / Wikimedia.org

*Spectrum* illustrates that spectroscopic methods work for studying electromagnetic radiation in general, not just the visible light.

# The quest to understand the spectral lines led to quantum physics and to the modern understanding of the structure of matter

- Explaining the spectral lines was difficult, since the structure of atom was not known
- Johann Balmer in 1885: a simple equation for spectral lines of hydrogen
  - Generalized by Johannes Rydberg

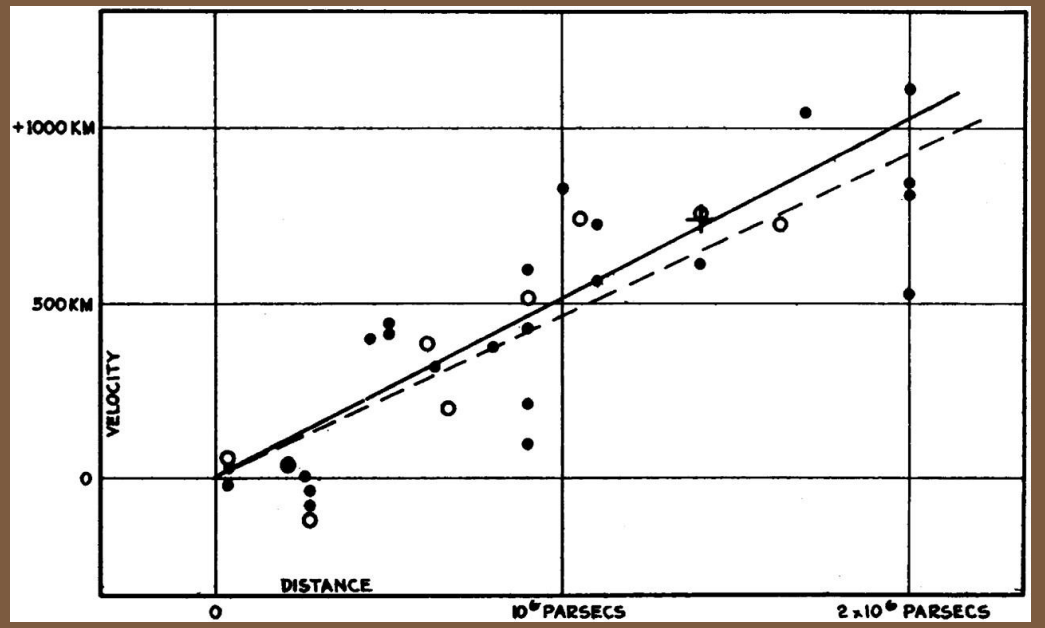
    $\frac{1}{\lambda} = R_H \left(\frac{1}{2^2} - \frac{1}{n^2}\right)$ for $n = 3, 4, 5, \ldots$
  - Works, but does not answer the question: why
- Bohr model of atom in 1913
  - Electrons revolve the nucleus in discrete orbits, where they have certain energies
  - The energy differences between the orbits corresponds to the wavelengths in the Rydberg equation
  - A primitive model of the hydrogen atom, but an important step towards modern quantum theory

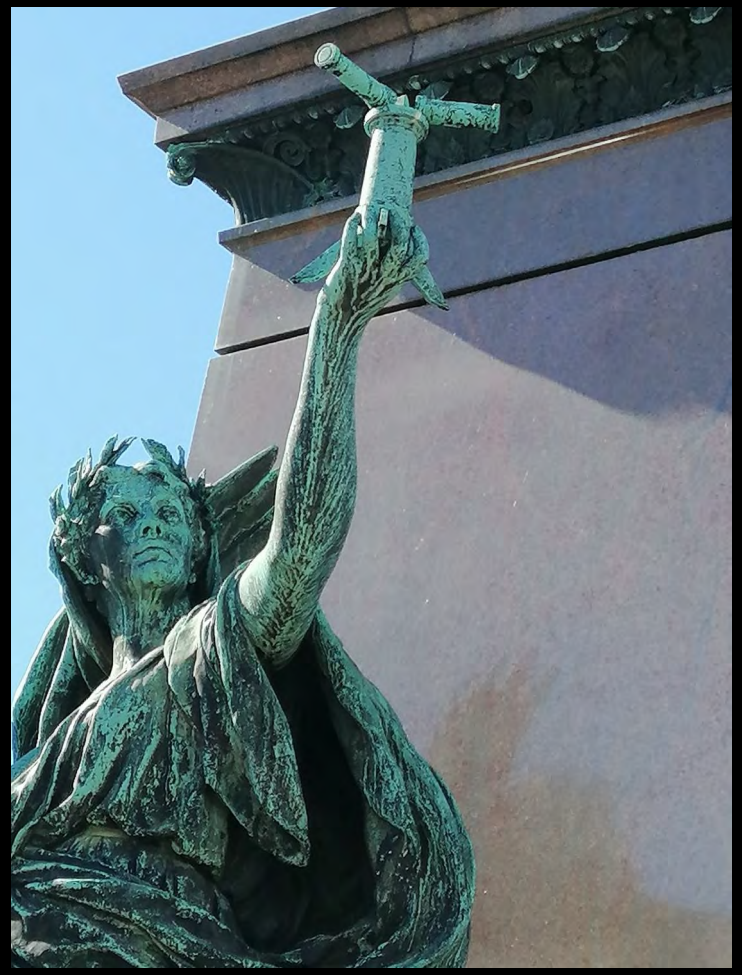


# Spectroscopy changed our understanding of the universe

- Vesto Slipher measures the Doppler shifts of ”spiral nebulas”
  - Almost all are moving away from Earth
- Edwin Hubble measures the distances at Mount Wilson Observatory
  - Combining the redshift measurements with the distances leads to Hubble’s law
    - ➢ galaxies are moving away from Earth at speeds proportional to their distance
- Hubble-Lemaître law can be explained by the expansion of the universe

Craig Baker / Wikimedia.org





The measurement instrument

The concept

The measurement data

Art can visualise science in many ways.

Thank you!