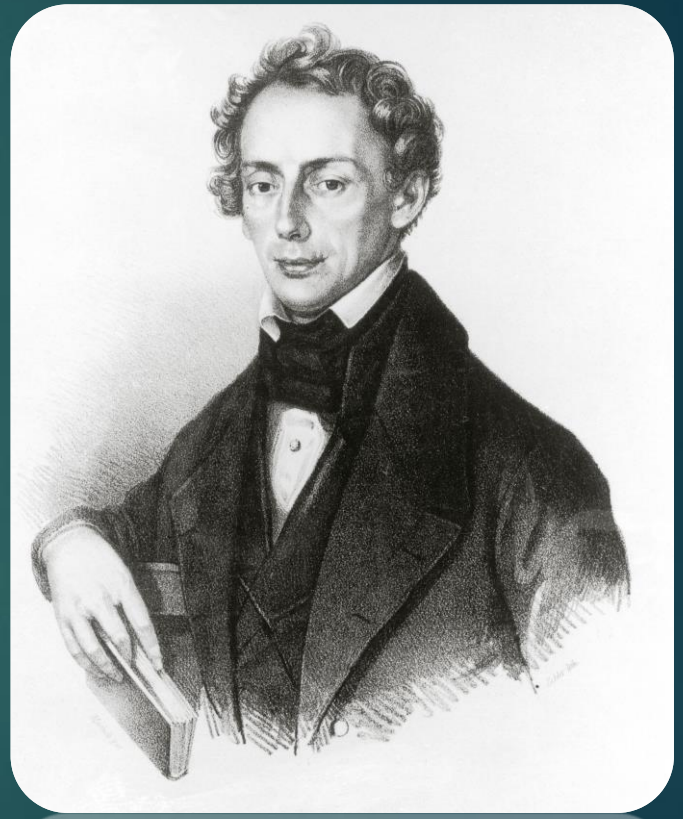
History of Doppler Effect

ALENA ŠOLCOVÁ, CTU IN PRAGUE



The Doppler Effect

is a change in perceived frequency motion of either caused by the source

or the observer.

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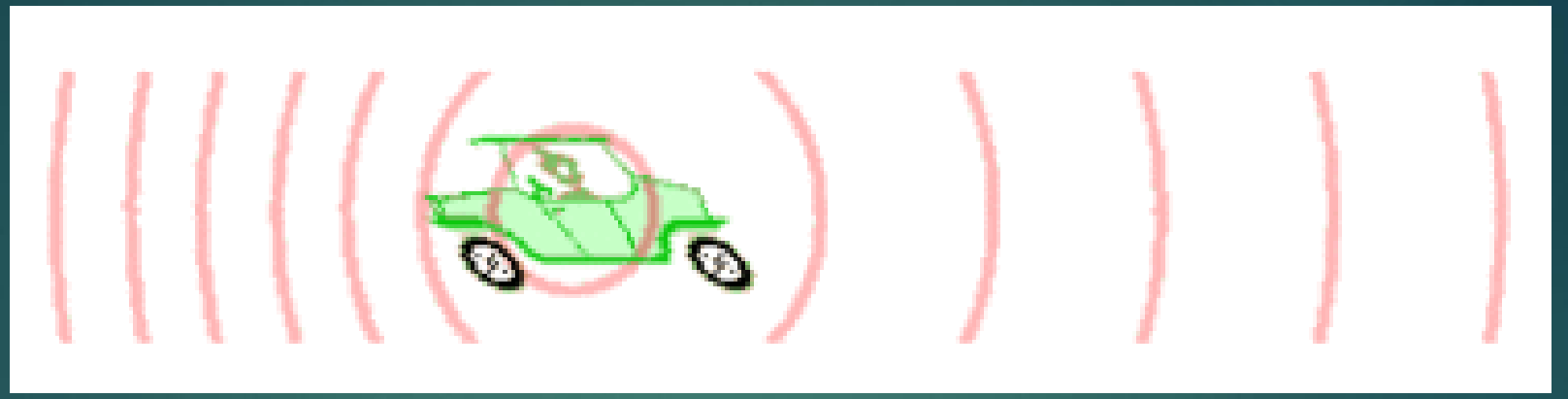

- How the Doppler Effect causes a car engine or siren to sound higher in pitch when it is approaching
  than when it is receding?
- The pink circles represent sound waves.

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Christian Andreas Doppler

29 November 1803

–

17 March 1853

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Doppler's Life and Career

- He was born on the 29th of November 1803 in Salzburg, Austria.
- Grandfather and father were noted master stonemasons.
- He could not follow the dynasty because of bad health.

Doppler's Life and Career

Education

- Primary school - Salzburg
- Secondary school – Linz
- Gymnasium - six year course in 2 ½ years, philosophical course in 2 years.
- He continued his studies in Salzburg privately.
- And the at the Polytechnic Institute in Vienna from 1822 to 1825, where Christian studied mathematics, physics and mechanics.

Early career:

1829 to 1833 - an assistant in advanced mathematics **at the Polytechnic Institute in Vienna.**

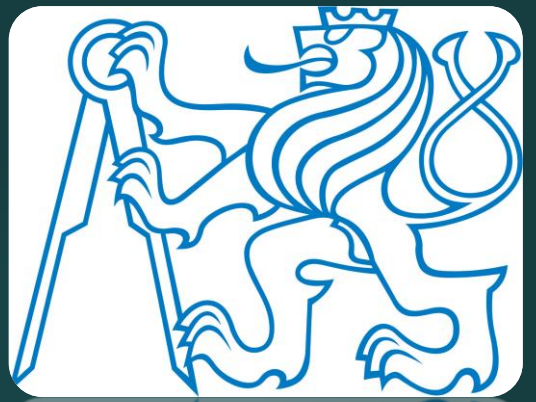
Scientific papers

"On the theory of parallels",
"Convergence of an infinite logarithm sequence",
"Likely cause of electrical stimulation through friction"

On the point of immigration:

- In 1835 Doppler was on the point of immigrating to America.
  He had sold his possessions and had reached Munich to contact the American Consul, when he obtained a position as professor of mathematics and accounting **at the State Secondary School in Prague.**

Success in Prague:



- 1841 he became professor of elementary mathematics and practical geometry at the Prague Polytechnic
(currently *Czech Technical University in Prague*)
- He had become an associate member of the Königliche Böhmische Gesellschaft der Wissenschaften
(the Royal Bohemian Society of the Sciences) in Prague in 1840
and was made a full member in 1843.

"Exceptional spiritual power combined with an amiable character, genuine unaffected determination and that pure love of science and truth which rises high above narrow-minded party-spirit as well as conceited inflexibility."

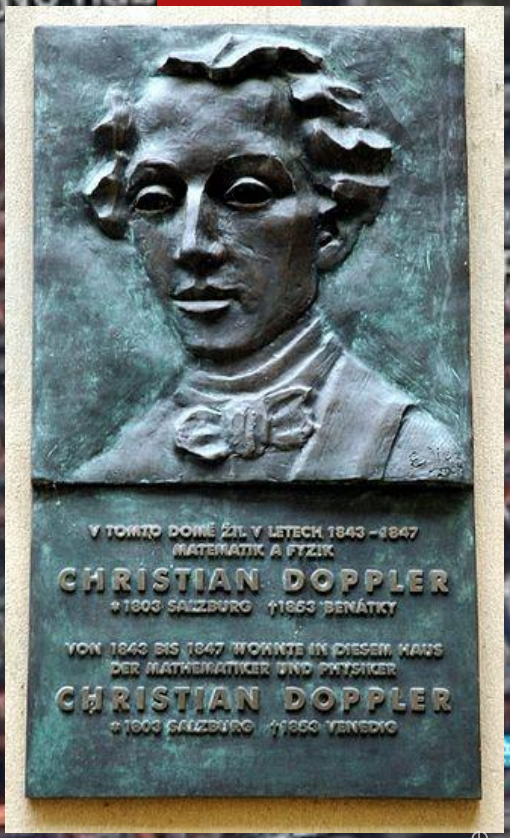
— *Bernard Bolzano*

Bernard Bolzano (1781 - 1848) - remarkable Bohemian mathematician, logician, philosopher, theologian

Family portrait 1844 (Mathilde is pregnant with their last child, Herrmann and the youngest daughter Bertha is missing on the portrait.)

- In 1836 he married Mathilde Sturm, a daughter of a gold and silversmith master from Salzburg.
- The Dopplers had 5 children.

Place of stay in Prague:



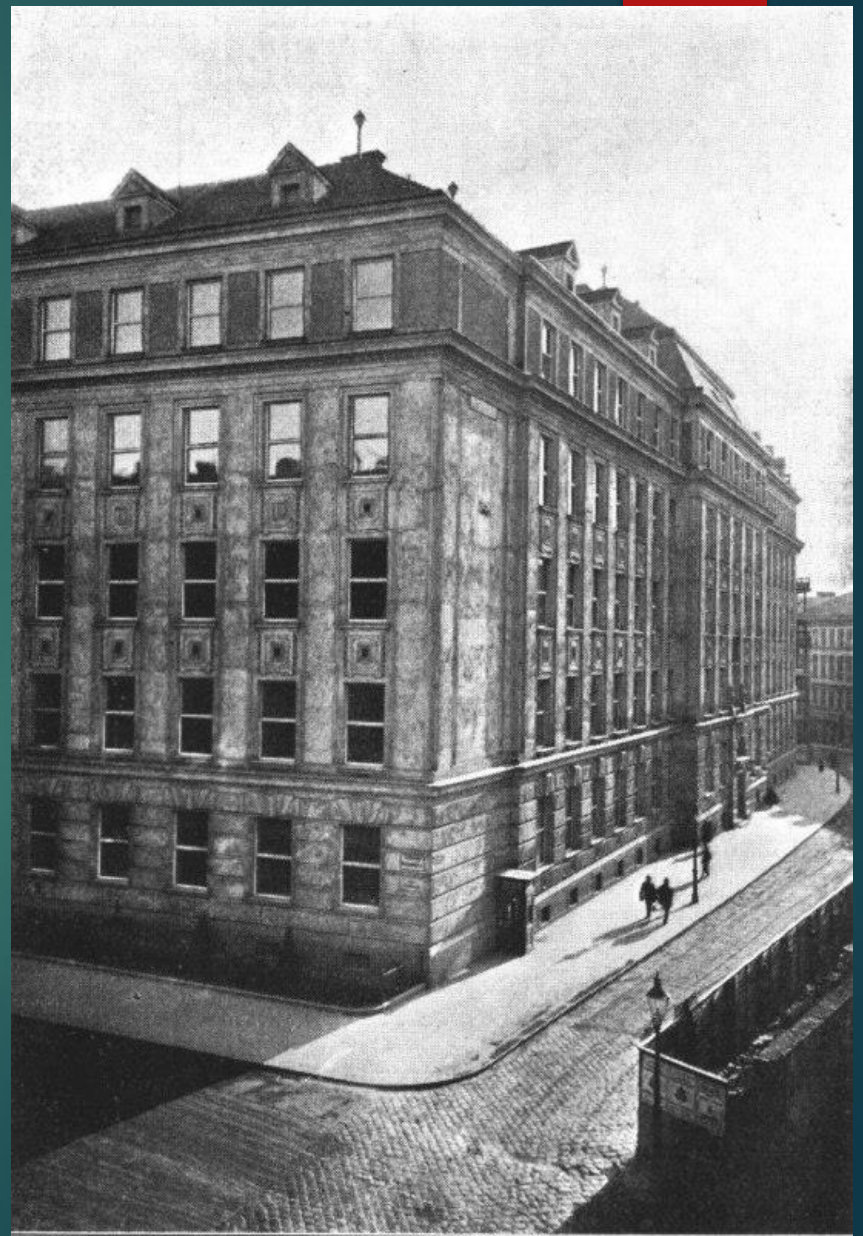
The Dopplers lived in the dwelling on the first floor of the house No. 799 on Kozi ul. 16 (currently) in Old Town of Prague.

To Upper Hungary – today Slovakia

- In 1847 CH. Doppler is the professor of mathematics, physics, and mechanics at the Mining Academy at Schemnitz (Banská Štiavnica) in Slovakia (today).

Back to Vienna

- In 1848–1849 he returned to Vienna.
- **1850 - director of the new Physical Institute, full professor of experimental physics at the Royal Imperial University.**



Last days in Venice

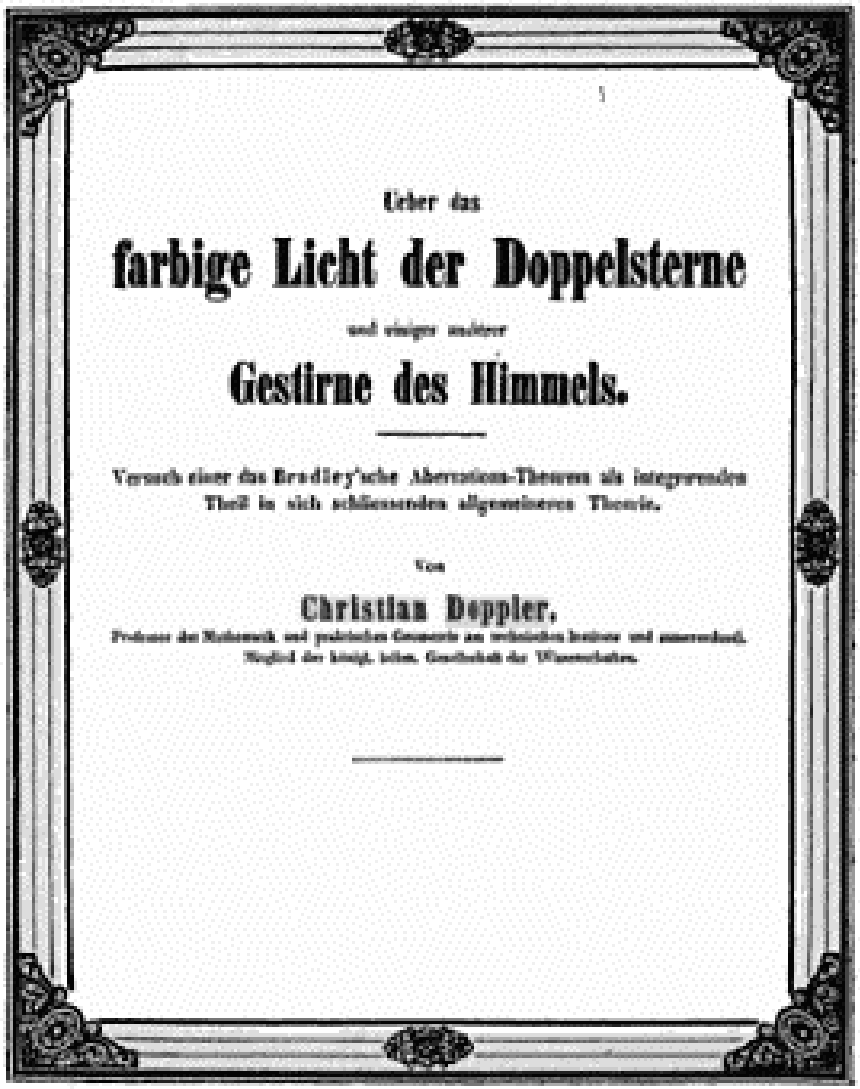
- Doppler developed a lung decease and in autumn of 1852 he requested sick leave. Following the doctor's advice he went to Venice, where **on 17 March 1853** he died in his wife's arms leaving behind five young children.

The body is buried in the cemetery of Venice where a monument was erected in his honour.

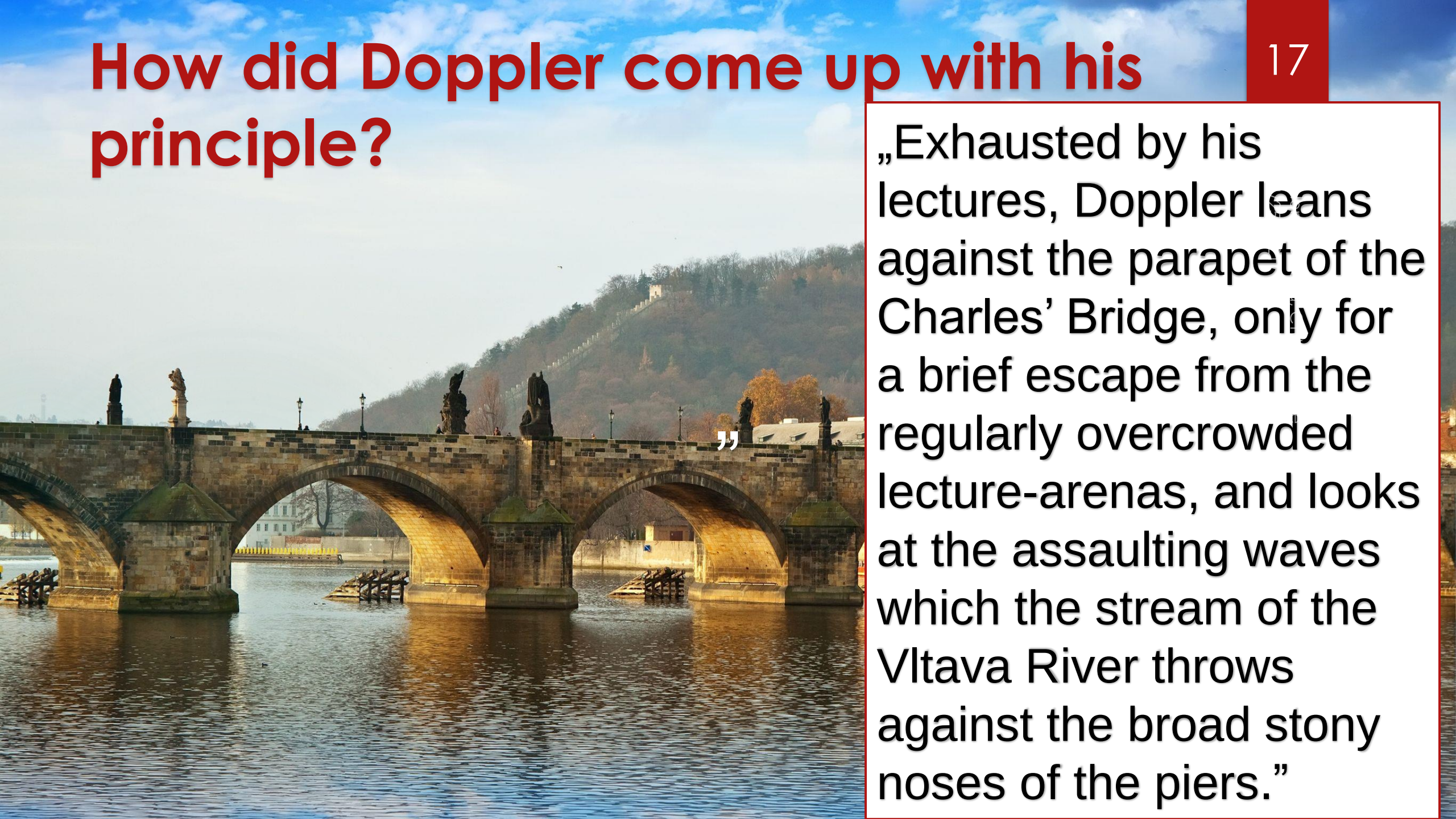
The Famous Lecture

On the 25 of May, 1842,
Christian Doppler on the session of the section of Natural Sciences of the Royal Bohemian Society in Prague Carolinum represented his paper
"Über das farbige Licht der Doppelsterne und einiger anderer Gestirne des Himmels"
(On the coloured light of the binary stars and some other stars of the heavens)

and ensured his scientific immortality and glory to Prague physics.


Ueber das
farbige Licht der Doppelsterne
und einiger anderer
Gestirne des Himmels.
Versuch einer das Bradley'sche Aberrations-Theorem als integrirenden Theil in sich schliessenden allgemeineren Theorie.
Von
Christian Doppler,

How did Doppler come up with his principle?



„Exhausted by his lectures, Doppler leans against the parapet of the Charles' Bridge, only for a brief escape from the regularly overcrowded lecture-arenas, and looks at the assaulting waves which the stream of the Vltava River throws against the broad stony noses of the piers."

The other assumption

It can be also assumed that one of numerous swans on the Vltava's bank had become another source of inspiration for Christian Doppler.

Doppler furthermore derived simple mathematical formula for frequency change in a non-comprehensible way, with some inconsistencies in notation. Nevertheless the formula was correct.
The relationship between received and emitted frequency is the following:

$$f = f_0 \left(\frac{c \pm u}{c \mp v} \right)$$

f_0 is the frequency of the source,
f is the frequency perceived by the observer,
c is the velocity of the wave in a stationary medium,
u is velocity of the receiver relative to the medium (positive if the receiver is moving towards the source and negative in the other direction)
v is the velocity of the source relative to the medium (positive if the source is moving away from the receiver and negative in the other direction).

Reaction of the Scientific Society towards the principle:

The Doppler's principle was hardly accepted without compromises.

Bernard Bolzano pointed out that Doppler's contribution was promising.
However, he was not in full agreement with Christian's mathematical computations.

Famous mathematician and optician Jozef Petzval in Vienna was absolutely in contradiction with Doppler

a "mere fraction", "small physics"

The long discussions based on misunderstandings between Petzval and Doppler, would lead to rapid deterioration of Christian's health.

Christophorus Buys Ballot' Experiment

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- In 1845 Christophorus Henricus Diedericus **Buys Ballot**, Dutch chemist and meteorologist (1817-1890) placed musicians with excellent pitch perception **along the railroad tracks between Utrecht and Maarsen.**

- **They estimated the pitch of the tone a horn player produced on board a moving train, as the locomotive approached and receded. The estimations of musicians confirmed the validity of the Doppler's Effect.**
- Although **Buy Ballot agreed with the acoustic assumptions**, hardly he believed in the application of the same principle towards the light (namely colours of the double stars).

The Buy Ballot's Experiment

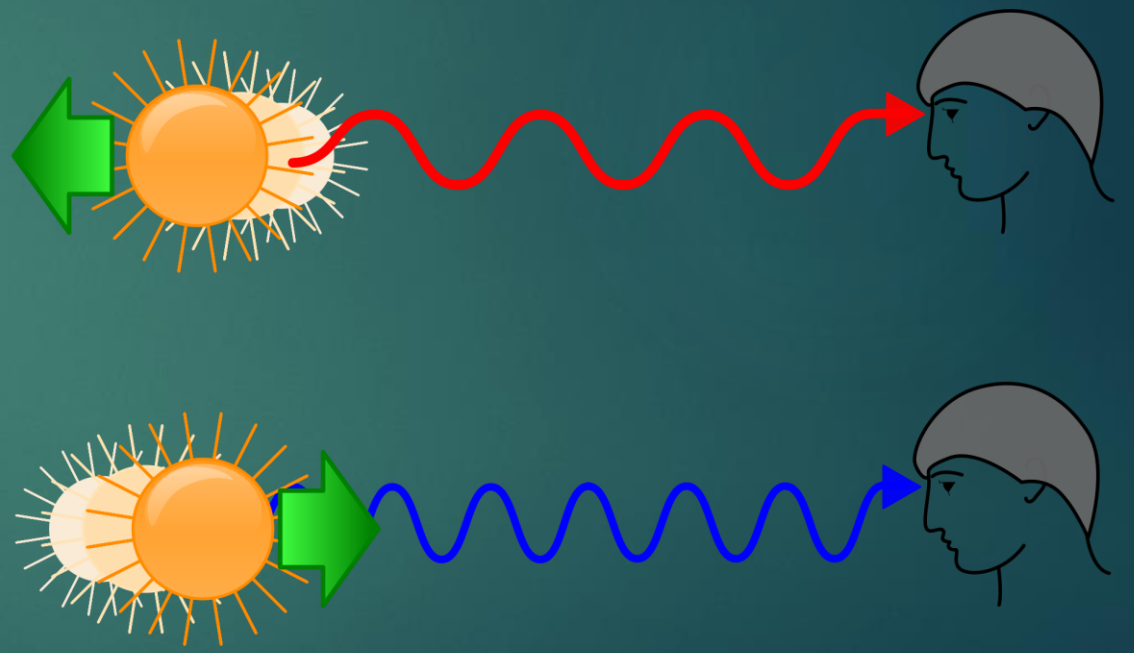
Applications in modern science and technology

- Astronomy
- Road Control
- Medicice
- Satellite Communication
- Audio,

etc.

Astronomy

- **Blue**/**red** shift of light – **speed** at which **stars** and **galaxies** are approaching **toward or receding from Earth.**



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Road control

- **Measurement of a car's velocity is usually carried out by applying the Doppler Effect.**
  A radar beam is fired at the moving target, receding the radar source.
- In some case **the gap between waves increases, raising the wavelength,**
  whereas in other cases the wave travels a lesser distances, decreasing the wavelength.

Medicine

- **The Doppler Effect also found its application in the echocardiogram,** which accurately determines the direction of blood flow and the velocity of blood and cardiac tissue at any point by means of velocity measurement of blood flow in arteries and veins.

LDV – Laser Doppler Velocimeter
ADV – Acoustic Doppler Velocimeter
UDV - Ultrasonic Doppler Velocimeter

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Others

- **Satellite Communication**
- Dynamic Doppler compensation
- **Audio -** The Leslie speaker

and many more

Conclusions:

Besides many scientific misunderstandings and absence of attention towards the principle, Christian Andreas Doppler did remarkable comprehensive work and made superior achievement, both in conceptual and practical application.

> *"No matter the shape the theory of electromagnetic processes should take, the Doppler principle will remain the same"*
>
> - Albert Einstein