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In November 2005, the world will celebrate the 202nd birthday of the physicist and mathematician who developed the famous “Doppler effect”. It was to remember the original thinker and to link his brightest ideas, 160 years after being published, to the different areas as medicine, astronomy, meteorology and spectrometry. Christian Doppler is decorated with many adjectives and is popular being a physicist but is often listed as a mathematician, astronomer and others, who gave us the tools to explore these divergent and different subjects.

His Life and Work

Christian Andreas Doppler (**Figure 1**) was born on 29 November, 1803 in Salzburg, Austria.^{1,6} He belonged to the family of master stonemasons who had a successful business in Salzburg since 1674. He had to take over the family business according to the tradition of those times but his parents decided to accept another career because Doppler’s health was never very good and was quite frail. Due to this he worked as a book-keeper for quite some time.

Doppler attended his primary school at Salzburg and secondary at Linz (Upper Austria). It soon became apparent that Doppler had outstanding talents in mathematics. His parents consulted the professor of mathematics at Salzburg Lyseum in 1822 who recommended that Doppler should study mathematics at new Vienna Polytechnic Institute (now Vienna University of Technology). He graduated in 1825 excelling in mathematics and other studies. After this he returned to Salzburg, attended Philosophy lectures and took classes in mathematics to support himself. This short period was followed by two years of higher studies in mathematics, mechanics and astronomy at the University of Vienna. It

Christian Andreas Doppler, Moving Stars and Rails in the Netherlands

Christian Doppler was an Austrian scientist who remains in history of science because of his discovery on Doppler Effect. The theory which was later proved experimentally has got a number of applications in various fields of science: in medicine, astronomy, physics, aviation and meteorology. Doppler ultrasonography has now become the main non-invasive modality for functional assessment of heart and blood vessels and has been extensively used to explore the abnormalities in vascular territories in brain, kidneys and other organs. This article aims to review the life and work of Christian Doppler and to review Doppler effect and its importance and applications in modern medicine.

Key Words: Christian Doppler, Doppler effect, medicine

was here that he was appointed assistant to professor A. Burg in 1829, when he published four mathematics paper , his first being , “A contribution to the theory of Parallels”.⁴ His assistantship unfortunately was only temporary and worst time of his youth followed. For months he was unemployed and even worked as a book keeper at a cotton factory, while he was seeking a permanent employment. During that time he applied to schools in Linz, Salzburg, Gorizia, Ljubljare, Vienna, Zurich and Prague, but alas, like other great scientists, including Einstein, Doppler became victim of serial rejections in response to his applications.⁴ This period of sadness and great difficulty even made him think about emigrating to the United States. Accordingly, he visited American consulate in Munich and sold his possessions to finance his journey. Unfortunately, the USA lost a great future citizen just because he was finally accepted as a professor at the technical secondary school in Prague.

During his stay in Vienna in 1836 he married Mathild Sturn, a native of Strasburg and soon fathered three sons and two daughters.

Christian Doppler presented an idea that subsequently immortalized his name. At a meeting of the Natural Sciences section of the Royal Bohemia Society in Prague, at the age of 38, on 25 May 1842, he presented the exotic paper *Über das farbige Licht der Doppelsterne* (Concerning the colored light of the double stars and certain other stars of the heavens).⁵ The stay in Bohemia was short and he rejoined his family in Vienna where he became the professor at the polytechnic institute in 1849. One year later on 17th January 1850 he was appointed as the first director of the new institute of physics at Imperial University Vienna-the highest point of his administrative career. Among the candidates Doppler



Figure 1. Portrait of Christian Andreas Doppler

examined at the Imperial University, was a 20-year-old monk, Johann Gregor Mendel. Professor Doppler was not impressed by his mathematical ability and Mendel was refused admission to the university. Mendel was finally admitted and later laid the foundation of genetics.⁷

Within months as the first director of the Institute of Physics at the Imperial University, he suffered from tuberculosis which later spread to the larynx and made speaking increasingly difficult. In November 1852 he traveled to Venice in the hope that the warmer climate would bring about some improvement. But hope sank as the disease progressed and on March 17, 1853 Doppler died from tuberculosis and was buried in Venice. The city of Venice honored Doppler with a 'grave of honor'.

Brilliant Doppler had difficult time throughout his career. Doppler published on magnetism, electricity, optics and astronomical topics but the paper called *Über das farbige Licht der Doppelsterne* (Concerning the colored light of the double stars and certain other stars of the heavens) which is now popularly known as the Doppler effect was the one which allowed him to remain in the history of science. He was certainly an original thinker and his ideas were quite revolutionary. His mind would continually come up with new ideas and it led to the invention of many instruments, particularly optical instruments.

Doppler Effect

Doppler Effect is the apparent change in frequency or wavelength of a wave that an observer moving relative to the source of the waves appreciates.⁸ To simplify it, as one approaches a blowing horn, the perceived pitch is higher until the horn is reached and then becomes lower as the horn is passed. In June 1845, a Dutch meteorologist from Utrecht, Christoph Ballot (1817–1890), proved the Doppler's principle on the railway between Utrecht and Amsterdam. He used locomotive capable of attaining the, at that time, incredible speed of 40 mph, to pull cart in which horn players were riding, Ballot observed changes in the apparent pitch of the notes played by the musicians as they approached or receded.⁷ Later that year Doppler set up an experiment using two groups of trumpeters, all of whom had perfect pitch. One group was set up at a train station while the other was set up on a train car that was to be pulled past the station. Both groups played the same note and Doppler's theory stated that the notes would be dissonant (that the frequencies would be different). The result came out to be true; the notes were audibly different, even though both groups of musicians played the same note.²

Besides sound the Doppler Effect is applicable to light. Doppler effect for light has been of great use in astronomy. It is used to measure the speed at which stars and galaxies are approaching to or receding from us. In addition the use of Doppler effect in astronomy is the estimation of the



Figure 2. Ultrasonography showing spectral waveform in stenosed carotid artery with high peak systolic velocity (219 cm/second)..

temperature of gas which is emitting a spectral line. This effect is commonly used in some form of RADAR (radio detection and ranging) to measure the velocity of detected objects. Among its many uses, radar is often used by police to detect speeding motorists as they recede from the radar source.

Doppler Effect and Medicine

Doppler principle was first utilized to detect cardiac motion and the opening and the closing times of the valves.⁷ Shigeo Satomura and Yasuhara Nimura at the Institute of Scientific and Industrial research in Osaka Japan used this principle for the study of cardiac valvular motion and the pulsation of the peripheral blood vessels.¹ A few years later, Rushmer (a Seattle-based pediatrician) with the help of engineers started transcutaneous continuous waveform measurement and the spectral analysis (Figure 2) in the peripheral and extra cranial vessels. Collagen et al applied Doppler principle to the investigation of fetal blood flow and enabled fetal circulation to study in detail in the year 1964.⁷ With the introduction of pulse wave

Doppler, localization of the flow velocity measurement to specific valves and chambers has been possible and even eased to localize murmur, determine orifice size from the jet diameter and to measure pulmonary flow and pulmonary artery pressure. Above all, it has made possible to determine the ejection fraction of the heart, one of the most valuable measurements in cardiology. It is also used in the valvular and vascular stenosis, deep vein thrombosis, prosthetic valves and estimation of chamber pressure.⁹ More over it is applicable to the diagnosis of congenital malformation of heart in-utero.⁹ To boast for its uses, it has replaced cardiac catheterization mainly in the children with congenital heart diseases to a large extent. Transcranial USG (ultrasonography) is used to analyze the blood flow through the arteries in brain to diagnose embolism, ischemia and hemorrhage and stenosis.

Subsequently with the introduction of pulse Doppler, transcranial continuous Doppler, color Doppler, power Doppler, tissue Doppler imaging, Doppler USG has become the main non-invasive modality for functional assessment of heart and vessels and its use is booming for its capacity to explore vascular territories like intracranial, renal, intestinal in addition to heart.

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