Lissajous, Jules Antoine | Encyclopedia.com

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(*b*. Versailles France, 4 March 1822;*d*. Plombières, France 24 June 1880)

physics.

Lissajous developed an optical method for studying vibration and was generally interested in the physics of wave motion. “Lissajous figures” are the curves in the *xy* plane generated by the functions $y = a \sin (w_1t + q_1)$ and $x = b \sin (w_2t + q_2)$, where w_1 and w_2 are small integers. The curves are today easily produced on an oscilloscope screen; but Lissajous obtained them in the context of acoustics, from the superposition of the vibrations of tuning forks. He entered the École Normale Supérieure in 1841 and received the agrégé in 1847. He then became professor of physics at the Lycée Saint-Louis. In 1850 he presented his thesis, *Sur la position des noeuds dans les lames qui vibrent transversalement*, to the Faculty of Sciences. In 1874 he became rector of the academy of Chambéry and, in the following year, of the academy of Besançon. Lissajous was a candidate for the physics section of the Paris Academy in 1873 but was only elected corresponding member in 1879. In 1873 he received the Lacaze Prize, primarily for his work on the optical observation of vibration.

Like some other physicists of the time, Lissajous was interested in demonstrations of vibration that did not depend on the sense of hearing. Most of his experiments involved visual manifestations of vibrations: in the thesis on vibrating bars he used Chladni’s sand-pattern method to determine nodal positions; he studied the waves produced by tuning forks in contact with water: and he did experiments on the popular phenomenon of “singing flames.” Lissajous’s most important research, first described in 1855, was the invention of a way to study acoustic vibrations by reflecting a light beam from the vibrating object onto a screen. He introduced his discussion of this topic with the assertion that, although sound vibrations are too rapid for direct observation, he could provide a visual demonstration of the wave form and obtain precise tuning without using the ear. (Lissajous was concerned with the problem of tuning—in 1855 he strongly recommended defining a standard frequency for the tuning of musical instruments.) He wrote that he thought of projecting the motion of vibration by reflecting light because he wanted to avoid the mechanical linkage present in some graphic devices (such as Duhamel’s). He claimed that the use of rapidly rotating mirrors in some contemporary experiments (such as that of his friend Léon Foucault, on the velocity of light) had influenced his thinking.

Lissajous produced two kinds of luminous curves. In the first kind, light is reflected from a tuning fork (to which a small mirror is attached), and then from a large mirror that is rotated rapidly. When viewed on a screen, the beam shows the trigonometric form of the displacements, because the vibrations have been “spread out.” The second kind of curve, named the “Lissajous figure,” is more useful. The light beam is successively reflected from mirrors on two forks that are vibrating about mutually perpendicular axes. Persistence of vision causes various curves, whose shapes depend on the relative frequency, phase, and amplitude of the forks’ vibrations, to be seen on the screen. For example, forks vibrating with the same amplitude and frequency produce ellipses the parameters of which depend on the phase difference between them.

Lissajous was interested in using his superposition curves to measure vibration parameters and to analyze more complicated acoustical problems. If one of the forks is a standard, the form of the curve enables an estimate of the parameters of the other. As Lissajous said, they enable one to study beats (the ellipses rotate as the phase difference changes), “Lissajous figures” have been, and still are, important in this respect. For further use in research Lissajous invented the “phonoptomètre,” a vibrating microscope in which a tuning fork is attached to the objective lens. The vibrations of the object being observed combine with those of the lens and can therefore be analyzed in terms of the Lissajous figures produced. Helmholtz used this instrument in his investigations of string vibration (Helmholtz, *On the Sensations of Tone*, Dover reprint, p. 80).

Lissajous’s optical method of observing vibration and the vibrating microscope were shown at the Paris exhibition of 1867 (they are described in *Reports of the United States Commissioners to the Paris Universal Exposition 1867* [Washington, D.C, 1870], III, 507-509), The French physicists awarded the Lacaze Prize to Lissajous for his “beautiful experiments,“and both Rayleigh and Tyndall discussed his work in their treatises on sound. Scientists were enthusiastic about the work because there were still not many ways of demonstrating and measuring the parameters of vibration. Lissajous’s optical experiments are simple, but the reasoning behind them depends on the principle of superposition; it is probably for this reason that they were done only in the middle of the nineteenth century.

BIBLIOGRAPHY

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On Lissajous's work, see "Prix Lacaze, physique," in *Comptes rendus hebdomadaires des séances de l'Académie des sciences,* **79** (1874), 1607-1610.

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