

MUSICOLOR - VISUALIZING MUSIC BY MEANS OF A SOAP FILM

GÖRAN RÄMME

Name: Goran Ramme, Physical Chemist

Address: Department of Physical Chemistry, University of Uppsala, Box 532, S-751 21 Uppsala, Sweden.

E-mail: goran.ramme@fki.uu.se

Fields of interest: Liquid surface sciences, specially soap films and soap bubbles.

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Abstract: *Many attempts have been made over the last centuries to make music visible. One obvious benefit of such an innovation would be to allow people with a hearing defeat to "see" the music. Thus, it has been a challenge to many scholars, musicians, artists, scientists and philosophers to realize this goal by various methods. One particularly interesting approach to visualizing music is to use a soap film that can easily be forced into acoustical vibration. The physical behavior of a soap film under these circumstances is similar to an elastic membrane, acting as though it was a "two-dimensional string". One can think of the vibrating soap film as the skin of a drum, set into vibration by the drumsticks. Directing homogeneous illuminating light onto the vibrating soap film and viewing the image of the reflected light on a screen presents a dynamic scene of remarkable beauty and fascination.*

1 INTRODUCTION

Many attempts have been made over the last centuries to make music visible. One obvious benefit of such an innovation would be to allow people with a hearing defeat to "see" the music. Thus, it has been a challenge to many scholars, musicians, artists, scientists and philosophers to realize this goal by various methods.

Sir Isaac Newton was intrigued by the close connection between optical and acoustical phenomena, and he realized that there is a direct correspondence between the seven colors of the rainbow and the seven notes of the musical scale. The frequencies of colors making up the visible light spectrum are harmonically related to one another in the same

way the notes on a tuned piano are. Specifically they are arranged in a natural scale called a diatonic scale.

The German physicist Chladni, at the turn of the eighteenth century, discovered a method to visualize vibration patterns. The so-called Chladni figures appear as wave patterns in sand, which has been spread evenly over a glass plate that is then set into vibration by a fiddle stick. The eminent Russian composer, Scriabin, made attempts to have the first performance of his symphony “Prometheus-Poem of a Flame” (1910) accompanied by correlated color changes, produced by means of a special instrument that he designed for the purpose. Today, modern technology has opened new possibilities within the field. A comprehensive review of the history of color and music by Tchouvilleva and Caglioti has been published in part by *Grillo*.

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In fact, acoustical properties of soap films were mentioned in *Nature* as early as 1878. In that journal were reported a simple and beautiful instrument, called the Phoneidoscope, that was constructed by Mr. Sedley Taylor. In the same article, work by professor Ernst Mach was also mentioned. He investigated the response of a soap membrane when exposed to sound.

In 1956 *Bergmann* investigated the fundamental vibrational modes of planar horizontal soap films with different geometries. More recently, the excitation of soap film membranes by music was reported by *Walker*. Since then, *Klein* and *Rajkovits* have reported variations and improvements of the original experiment. A theoretical treatment of vibrating soap films can be found in the book by *Isenberg*.

2 EXPERIMENT

The equipment used is depicted in Fig 1. A common slide projector served as a light source and a positive lens was placed between the projector and the soap film in order to collimate the light and illuminate the central part of the soap film uniformly. The planar, vertically hanging soap film acted as a mirror and the reflected light was projected onto an overhead screen by means of a large, plano-convex lens. The lens optimized the clarity of the image of the soap film on the screen. The soap film was attached to the circular open end of the hemispherical cover of a plastic desiccator. A micro size loudspeaker was mounted instead of the stopcock. The frequency range of the loudspeaker was 70 - 6400 Hz. It had a maximum power of 0.2 W. In order to change the curvature of the

soap film for specific purposes, the cover was provided with means for adjusting the air pressure in the cavity between the soap film and the loudspeaker.

The geometrical boundaries of the soap film determine the structure of the observed vibration pattern. In order to study the effects of boundary conditions, the circular rim of the holder for the soap film can be replaced by other boundary profiles (square frames, for example). A ring of slightly larger diameter than the holder is used to apply soap film to the rim of the holder. The ring was made from a piece of 6 mm diameter plastic tubing. At the start of the procedure for producing a soap film, the rim must be soaked carefully with soap solution using a cotton wad before applying the film. The holder was held by a stand designed for easy adjustment to get the soap film to hang vertically or at any desired angle.

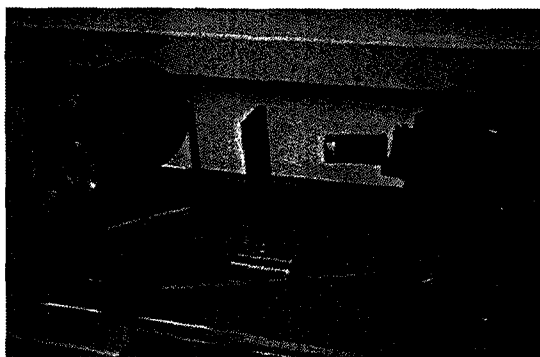


Fig. 1

To be suitable for displaying the vibrations excited by a piece of music a soap film should have a sufficiently long lifetime. A soap solution first recommended by Kay is tough enough for this purpose. A circular soap film of a diameter of about 10 cm survived more than half an hour without requiring any special protective measures.

A planar soap film that is hanging vertically has a trapezoidal shape as viewed from the side and it becomes gradually thicker towards the lower part of the film. Immediately after formation of a new film, liquid flows down the film mainly due to gravity. Soon an equilibrium state is achieved. At any horizontal level height in the film, the thickness is uniform. Rainbow color bands appear on the film whenever incident light that is reflected both from the front surface and the rear surface experiences constructive interference. If this does not happen, the film shows no color. The relation between the particular incident wave length of the light and the thickness of the film determines whether the interference is constructive or destructive.

In particular, when Kay's soap solution, based on glycerine, is used, there is no thinning of the film over time due to the absence of evaporation, and there is also lack of

turbulence. Consequently, this kind of film becomes very stable shortly after its formation and shows a sequence of stationary horizontal bands in the colors of the rainbow. On the other hand, if the soap film is excited by the impact of sound, liquid streams appear in the film changing its thickness and, accordingly, producing a variation in observed colors.

The music for exciting the soap film must next be selected. Rock and pop music have been reported to produce excellent results. The optical show that accompanied the playing of "The Planets" by Gustav Holst (composed between 1914 and 1917) was particularly fine and added an extra dimension to the performance. Vibrations in the loud speaker membrane induced by the music are transferred to the soap film by fluctuations in the air pressure. On the screen, one can observe a number of oscillating concentric nodes and antinodes originating from the central part of the circular film. The oscillations respond to the variations in intensity and pitch of the music. Eventually, the film will go into resonance with the sound for suitable frequencies. Under these circumstances, one can observe violent movements and dancing of the colors on the film, in part synchronized with the music. The thickness of the film is affected by the fluctuations, leading to the development of vortices and outbursts of two symmetrical branches of liquid streams. The streams originate in the central part of the circular film and resemble a sprinkling fountain

3 CONCLUDING REMARKS

It is remarkable that such a thin object as a soap film membrane, of a thickness of the order of 10^{-7} m, can survive vibrations of several thousand cycles per second and the considerable changes in size and shape of the membrane that occur due to the extension and contraction during every period. A music color performance using a soap film membrane is indeed a manifestation of harmony, simplicity and symmetry, all concepts belonging to the beautiful framework of physics.

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