contrast in neighboring bands of gray appears to be enhanced when the bands are touching, a phenomenon called the Mach band effect. I have seen such a model in technical papers but never in a popularization.

Although I don't view the book as successful, I respect the author's courage in writing about fields—from evolutionary teleology to cinematography—that are far from where he began.

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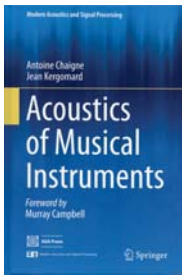

Acoustics of Musical Instruments

Antoine Chaigne and Jean Kergomard

Springer, 2016. $279.00 (844 pp.). ISBN 978-1-4939-3677-9

Our experience of sound is created by the motion of the air around us. That motion arises from the movement of nearby objects, whether machines, mosquitos, or musical instruments. Many authors have collected and organized the mathematical equations that predict the motions of the air. Perhaps the first to do so comprehensively was Lord Rayleigh. His *Theory of Sound* (1877, 1894) included everything he could find on the topic, organized in a logical development of ideas and math and largely rendered in the language of differential calculus. It was a singular achievement in its day, and so acute that physicists can still learn much from it.

One of Rayleigh's distinctive contributions was his careful demonstration of the construction of his mathematical models, revealing the assumptions and compromises that limited their predictive abilities. Some of his derivations were unambiguously solid; others employed compromises significant enough to invite the reader's consideration. With characteristic candor, he prefaces the second edition with a confession to his readers: "The pure mathematician will complain, and (it must be confessed) sometimes with justice, of deficient rigour, [but] the physicist may occasionally do well to rest content with arguments which are fairly satisfactory and conclusive from his point of view."

In *Acoustics of Musical Instruments*, Antoine Chaigne and Jean Kergomard have applied mathematical rigor with comprehensive scope, and the result is remarkable. The authors show the readers how each model of musical instrument acoustics is constructed and discuss the effects of assumptions and approximations. The level of detail they provide gives readers greater confidence in what each model can do—and a firmer understanding of what it cannot. Their observations drive them to build ever more effective models, many using ideas that were not available in Rayleigh's time.

Since musical instruments usually depend on vibrations to generate sound, the authors begin with the simplest equations describing bound motion and oscillation. They expand into traveling waves, modes of vibration, and damping and coupling, and they incorporate nonlinear and discontinuous behaviors. Finally, they model the complexities of design and operation of typical musical instruments, including wood and brass winds, violins, guitars and pianos, and various percussion instruments.

Each kind of instrument is given close attention, as is the listener's orientation with respect to the instrument, since musical instruments often drive different air motions in different directions. The authors' attention to wind instruments is necessarily more extensive in order to encompass those instruments' wider variety of input and output. Unlike string and percussion instruments, whose vibrating parts are made of solids that are relatively unchanging, wind instruments do not themselves vibrate significantly. Instead, they contain air that vibrates. Those vibrations are driven by motions of air inside the performer and are deeply affected by interactions with the air surrounding the instrument. The necessary models predicting the vibrations are developed over several dedicated chapters.

The authors use Newtonian mechanics for their initial simple models, then refine them by incorporating concepts from finite math, thermal and fluid dynamics, structural analysis, and dynamic systems. Although other books take a similar approach, Chaigne and Kergomard distinguish themselves by patiently introducing their topics, developing and assessing the math, and explaining their subject in a way that prevents any confusion or misunderstanding.

Readers also benefit from the authors' substantial investment in the book, which they have improved through several editions; this is the first English edition of the valuable text, which had earlier appeared in French. Chaigne and Kergomard have drawn from an immense collection of both theoretical and experimental sources, which has yielded a resource that is current, thorough, and packed with citations that can lead readers to deeper exploration.

Chaigne and Kergomard's magnum opus sets a high standard for logical and mathematical rigor in musical-instrument acoustics. The text and math are lucid throughout and should be easily understood by readers with a basic grasp of mechanics. The authors are justified in recommending the book to "students at master's and doctorate levels [and] researchers, engineers and other physicists with a strong interest in music"—each of those groups will find the information they need in *Acoustics of Musical Instruments*.

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