Color of sound

Sound is a longitudinal mechanical wave that a person is able to perceive in the range of 16 Hz–20 kHz. Together with pitch (given mainly by the frequency f) and intensity (given by the square of the amplitude A), we also recognize the **color** of the sound. Sounds with a sinusoidal waveform are called **simple** tones. **Tone is, in contrast to noise,** characterized by one significant frequency, several tones with different pitches form a **chord**. Noise usually has the entire range of frequencies spread out continuously (**white noise** uniformly, **pink noise** with a predominance of lower frequencies).

Compound tones with the same pitch f (fundamental frequency) differ from each other in color, which is mainly determined by the presence of the so-called **higher harmonics**, i.e. tones with a frequency of an integer multiple ($2f$, $3f$, $4f$etc.); the time course of the tone envelope also affects the color. We call a tone of twice the frequency **second harmonic** (triple third, etc.). A compound tone with frequency f can be expressed as a sum of sine waves: $\sum_k A_k \sin(2\pi k f + \alpha_k)$with **amplitude** A_ka with **phase shift** α_k. This decomposition of the composite tone is performed by **Fourier analysis**. Differences in the ratio of higher harmonics create different tone colors; however, phase shifts cannot be distinguished by the human ear. Odd harmonics sharpen the sound, while even harmonics soften the sound.

Fourier analysis can be performed for any sound, even for noise; frequencies can then be arbitrary, not just multiples of some fundamental frequency.

Sound color is key in the ability to distinguish human voices and tones produced by playing different types of musical instruments. So far, it has not been clarified how the decomposition of sound is realized in humans. The different color of the sound is due to the different characteristics of the sound source (shape, size, material, ...).

🔎 *For more information see Tone Color.*

Links

related articles

- Acoustics
- Sound properties
- Propagation of acoustic waves
- Volume
- Pitch
- Biophysics of hearing

Resources

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