Playing Music with Molecules:
a Spectroscopic Symphony for Scientific Education and Engagement

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Quantum physics is an essential component of Physics education, reflecting the increasing relevance of quantum science and technology in our world. Teaching quantum physics, however, is challenging for a number of reasons: students can lack the mathematical background to delve into quantum formalism, and quantum phenomena often contradict classical models with which students are used to thinking. Consequently, conventional quantum pedagogy requires students to adopt radical conceptual changes.

On the other hand, many concepts in quantum physics share a direct correspondence with musical phenomena. The Heisenberg uncertainty principle, for example, can be explained by appealing to commonly understood acoustic concepts: the shorter the duration of a sound, the larger the spread of frequencies required to represent that sound. Conversely, sounds with tight clusters of frequencies have longer durations. This acoustic 'Fourier' uncertainty principle limits the precision of the simultaneous measurement of the duration and frequency of a sound in exactly the same fashion as simultaneous measurements of conjugate variables in the quantum world.

In this talk, I will detail the practical methodology we have developed to musically interact with quantum mechanical systems. This is the result of the frequency overlap between the electromagnetic radiation absorbed and emitted by molecular nuclei in a nuclear magnetic resonance (NMR) experiment, and the audio range of human hearing. By encoding musical signatures into optimised quantum NMR control protocols, we are able to excite precise combinations of molecular energy levels, and then listen to the signals they produce in real time. Tuning the molecular species comprising our ensemble allows us to implement specific musical keys signatures, and 'jam' with a variety of tuned molecular ensembles.

This is an exciting and novel platform for scientists to engage with both students and non-scientific audiences to communicate the concepts behind the quantum science. We anticipate that integrating this approach into physics education will lead to a more inclusive learning experience, and will enable increased public interest in quantum research by providing a platform to communicate complicated concepts in an entertaining manner. Such an approach has significant potential to attract more students to undertaking STEM pathways by emphasising fun and engaging applications.