Physics 5C: Introductory Thermodynamics and Quantum Mechanics **Fall 2023**

Homework 04, Due October 12

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Attosecond Physics : A Glimpse into the life of electrons

On October 3, 2023 the Nobel Prize in Physics was awarded to Pierre Agostini, Ferenc Krausz, and Anne L'Huillier for their contributions to experimental methods of generating *attosecond pulses of light*. But why was this such a big deal? And what novel frontiers of research does *attosecond physics* open up to us?

How Attosecond Pulses are Generated:

- The breakthrough method which was the cause for this Nobel Prize to be awarded is *High-Harmonic Generation*.
- This method makes use of a non-linear interaction between gaseous molecules and a laser light to generate extremely sharp burst of radiation – on the attosecond scale.

Why is this particular time-scale important?

- In previous years, experimental methods of producing radiation on time-scales all the way down to Femto-seconds ($10^{-15}s$) were pioneered. These are *incredibly* fast pulses of light.
- However, when it comes to studying **electrons** – particles whose behavior essentally dictate all of chemsitry and much of physics – that's simply not fast enough.
- Electrons travel on the time-scale of Attoseconds i.e. $10^{-18}s$. So, being able to produce light pulses on this time-scale means we can *directly study the motion and interactions of electrons!*

So, what can it be used for?

- As mentioned earlier, attosecond physics allows us to study the real-time motion of electrons.
- Studying the motion of electrons withnin a molecule can tell us about its *shape* and various other properties. This could aide in a variety of fields such as Biology and Medicine (eg. studying the shapes of enzymes/proteins etc. that could propel Medicine synthesis), Materal Science, and many other fields.

But what about its applcations *in Physics*?

- Within physics, too, this breakthrough opens up new frontiers.

- Some interesting applications include

    1. Watching Quantum Interference build up over time
    2. Directly Observing the Oscillations of the Electric Field.

    Developments like the one regarding osciallations of the electric field not only further physics, but also give us more to work with when thinking about the *philosophy* of physics.

    In conclusion, Attosecond physics allows us to peer deeper than ever before and gves us a multitude of options to explore for future research.

Bibliography:

1. https://physics.stackexchange.com/questions/782972/what-is-an-attosecond-pulse-and-what-can-you-use-it-for

2. https://www.youtube.com/watch?v=O$_T dEceEpsw$