Lecture 3: Spectroscopy Done Right!

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1. **Review of Atom-Light Interaction Basics**
2. **Review of two-level systems.**
3. **Wigner-Weisskopf Theory and Atomic Linewidth**
   - Introduce the theory of spontaneous emission.
   - Detailed discussion on linewidth: line-shape, angular distribution of emitted photons.
4. **Spectroscopy Fundamentals**
   - Overview of different spectroscopic methods.
   - Introduction to line broadening mechanisms.
5. **Broadening Mechanisms in Spectroscopy**
   - **Homogeneous Broadening:**
     - **Natural Broadening**
     - **Power Broadening** and its physical origin.
     - **Collisional Broadening** and its implication in precision measurement.
   - **Inhomogeneous Broadening:**
     - **Doppler Broadening**
     - **Field-gradient-induced Broadening** (Stark and Zeeman)
6. **Strategies to Overcome Broadening Effects**
   - **Doppler-free Saturation Spectroscopy**: Outline method and applications.
   - **Ramsey Interferometry and Echo Pulses**: Introduce methods to mitigate certain broadening effects.
7. **Systematic Shifts in Spectroscopy**
   - Discuss impacts of Zeeman shifts, AC Stark shifts, blackbody radiation shifts, and collisional shifts on precision spectroscopy.
8. **Case Study: Beating the Natural Linewidth Barrier**