Quiz 10: Quantum Physics II

Lasers can be seen in places other than CD players and the Martian atmosphere. In particular, when gasses in stellar envelopes are cooled, a population inversion is established, and the resulting laser action amplifies lines in the star’s emission spectrum.

Here we consider the He I emission observed in star “MWC84.” Astronomers detect an unusually strong emission line corresponding to the transition between energy levels $E_{10}$ and $E_5$ in helium (for those interested, these are the $3^1D$ and $2^1P$ states). Relative to the ground state ($E_1 = 0 \text{eV}$), these levels have energies of $E_5 = 21.2 \text{eV}$ and $E_{10} = 23.1 \text{eV}$.

1. Why is a population inversion required for laser action?

2. What wavelength is emitted by this natural laser? What part of the EM spectrum does it lie in?
3. In most lasers, electrons are “pumped” up from their ground state to a metastable state. In this case, however, free electrons are captured by atoms as they cool and “cascade” from high-energy states to a metastable state. At the end of this cascade, are more electrons found in state $E_{10}$ or in state $E_{5}$?

4. How is the radiation from this helium laser similar to that from a laboratory laser using an optical cavity? How is it different? Try to address at least three properties.

5. (optional) What are your favorite and least favorite topics in electricity and magnetism?