Xiaolin Bian

From Throwing Stones to Photon Emission: How to Make a Larger Water Splash?

Imagine that you are on summer vacation with your family in a summer lake house. It is a sunny afternoon, and your father is swimming while you are throwing pebbles into the water. At first, you pick up ten pebbles and throw them into the water one by one, but to your disappointment, this does not cause large water splash; so the second time, you decide to throw ten pebbles at the same time to make a huge splash and you make it! This time the splash is much bigger and caused a huge noise. You successfully annoyed your father who is swimming near shore and get a real tongue lashing.

Fig. 1 A boy throwing stones (Image Source: StoryBlock)

What is described above is the idea behind superradiance. The only difference is that in our case, the “pebbles” here are “excited atoms”. Excited atoms can decay from an upper energy level to a lower energy level by emitting a photon, if we have ten excited atoms, under natural circumstances, these ten atoms will de-excite independently, just as we throw ten pebbles randomly into the water. The radiation field is simply proportional to the number of atoms involved. However, if we can make the atoms de-excite coherently—which means, we make the atoms de-excite from the upper energy level at the same time, the radiation intensity will be much stronger—proportional to the square of the number of atoms. Fig.2 compares the two different pulse: independent emission and superradiance pulse of ten atoms.

This intensity enhancement phenomenon is called superradiance. It is first proposed by Robert H. Dicke in 1954. Physicists soon realized how this phenomenon could be used to increase the lasing intensity of the existing laser systems and also to shorten pulse duration. The main objective of this study is to contribute toward a comprehensive understanding of the superradiance problem in a short wavelength regime (100 to 100 eV). In this regime, superradiance is influenced by Auger effect which would compete with normal superradiance process, and we want to study if it is possible to generate ultra-short pulses on the femtosecond or attosecond timescale using Dicke superradiance.

Supervisor: **Marcus Dahlström**
Degree project 30 hp in FYSM30 2019
Department of Science, Lund University