OBSERVATION OF SUPER- AND SUBRADIANT SPONTANEOUS EMISSION OF TWO IONS

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- Super- and Subrradiance
- Experimental Techniques
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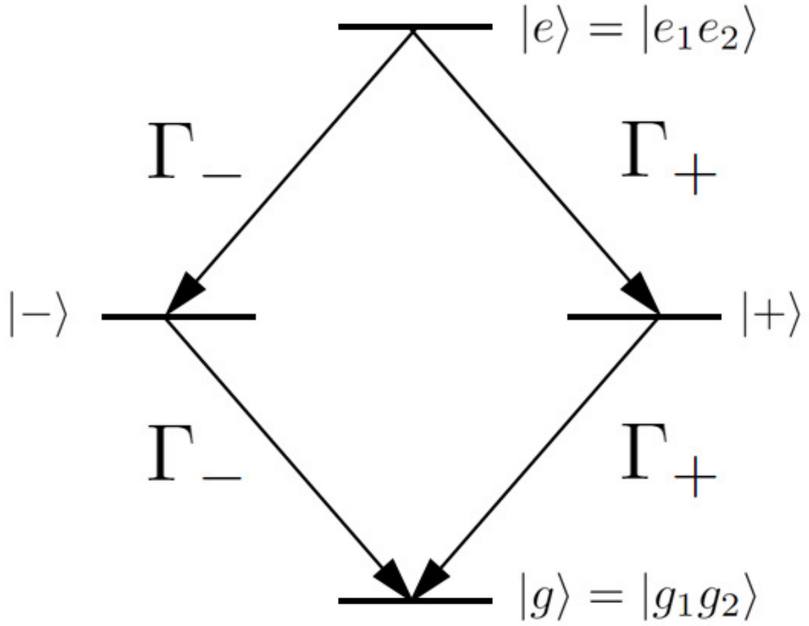
SUPER- AND SUBRRADIANCE

R. H. Dicke. **Coherence in Spontaneous Radiation Processes.** Phys. Rev. 93, 99 – 1 January 1954

In Dicke's theory, instead of treating the two-level atoms independently, we approach the system as a single four-level atom.



$$|\pm\rangle = \frac{1}{\sqrt{2}}\left(|g_1 e_2\rangle \pm |e_1 g_2\rangle\right)$$

SUPER- AND SUBRRADIANCE

$$\Gamma_{\pm}(R) = \Gamma_0 \left(1 \pm \frac{3}{2}\frac{\sin kR}{kR} + ...\right)$$

superradiance been $\Gamma_{\pm} > \Gamma_0$

and subradiance $\Gamma_{\pm} < \Gamma_0$

$$W(R,t) = \rho_e(t)\left[\Gamma_+(R) + \Gamma_-(R)\right] + \rho_+(t)\Gamma_+(R) + \rho_-(t)\Gamma_-(R)$$

The decay curveproduced by the photon statistics is given by the sum of the four transitions

$$\rho_{\pm} = |\rho_{eg}|^2(1 \pm \cos\Phi)$$

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$$\Phi = \vec{k} \cdot \vec{R}$$

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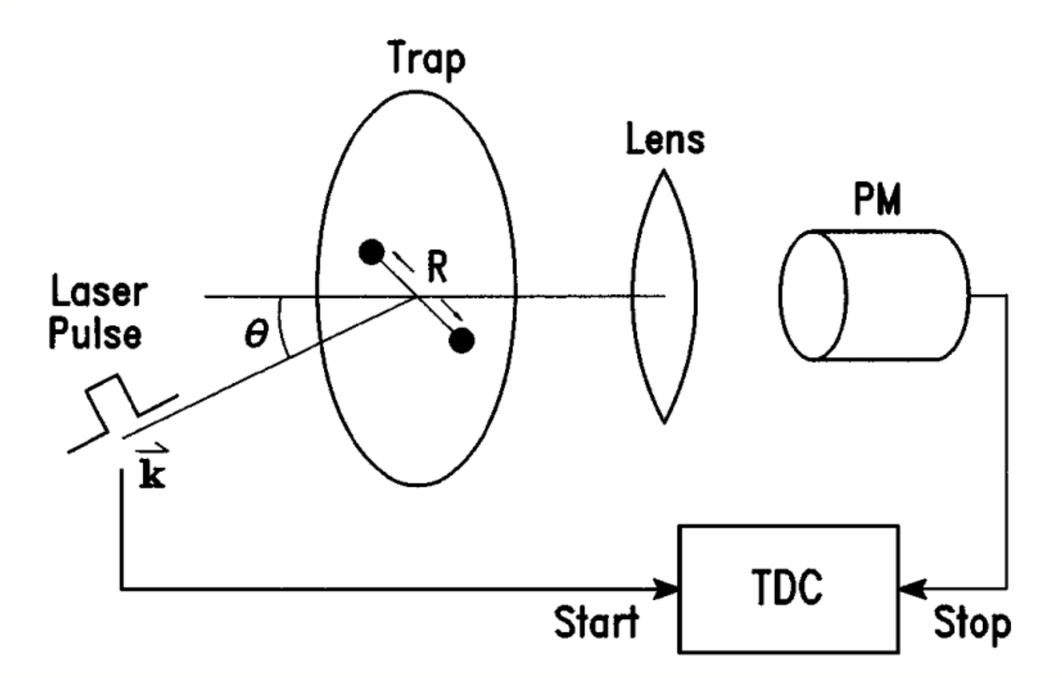
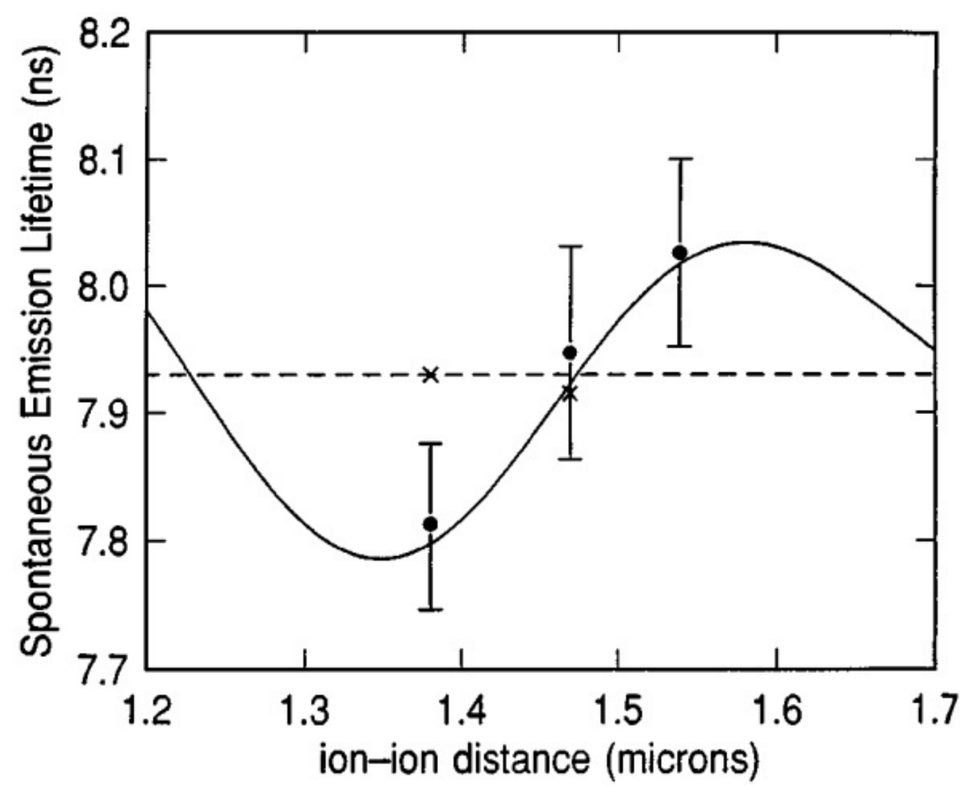
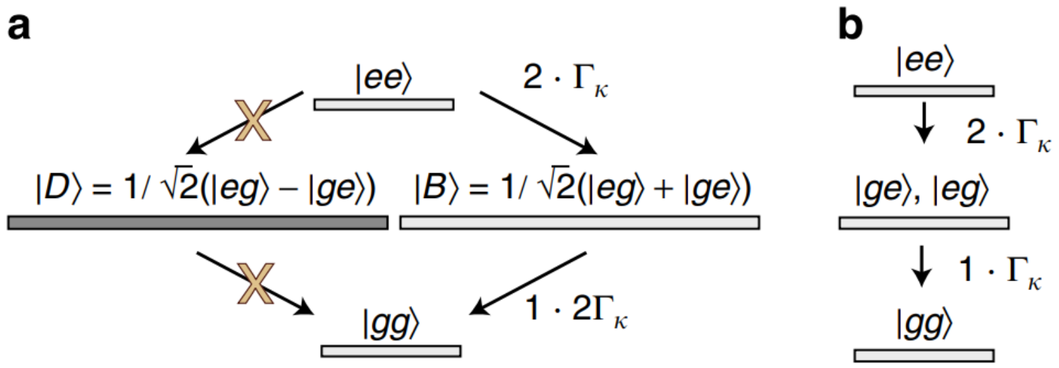


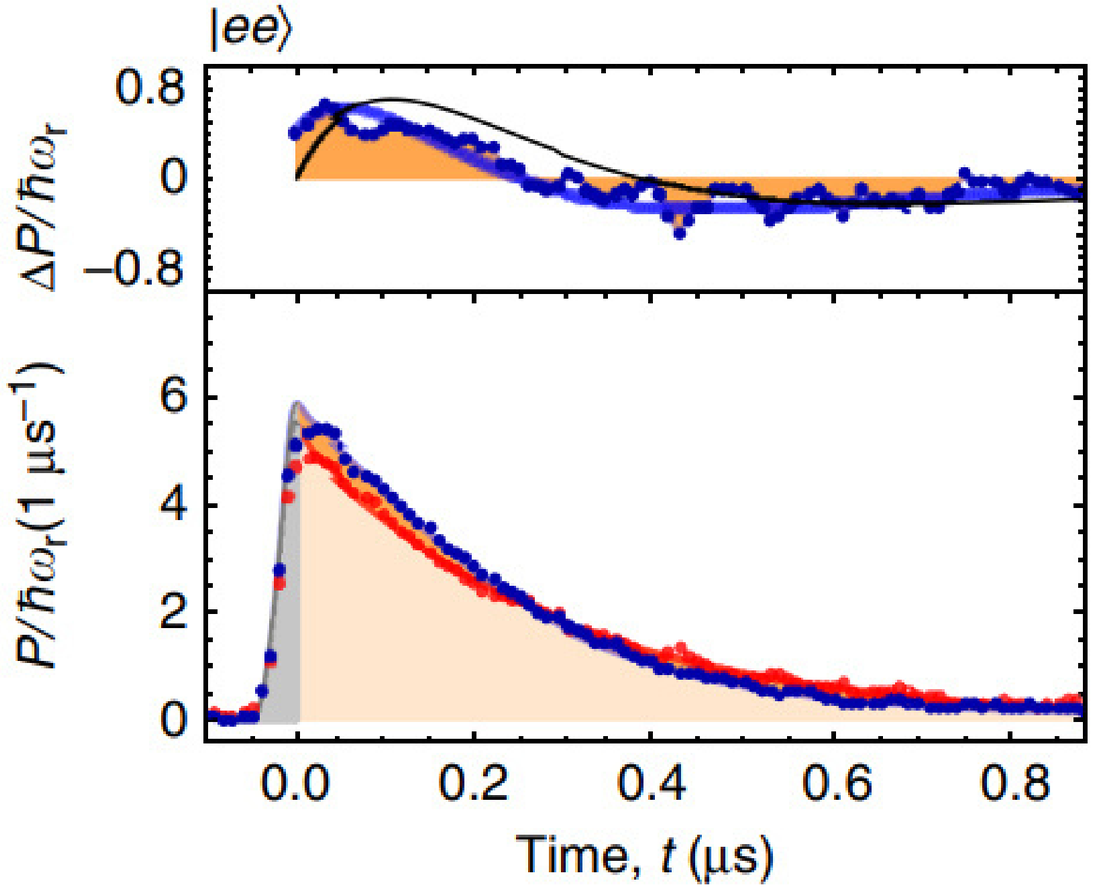
Diagram of the experiment [deVoe and Brewer, 1996]



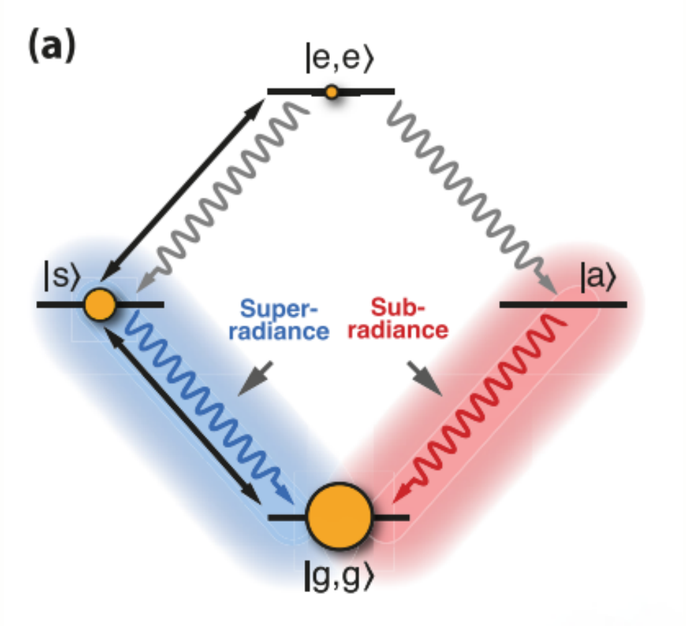
SUPER- AND SUBRRADIANCE



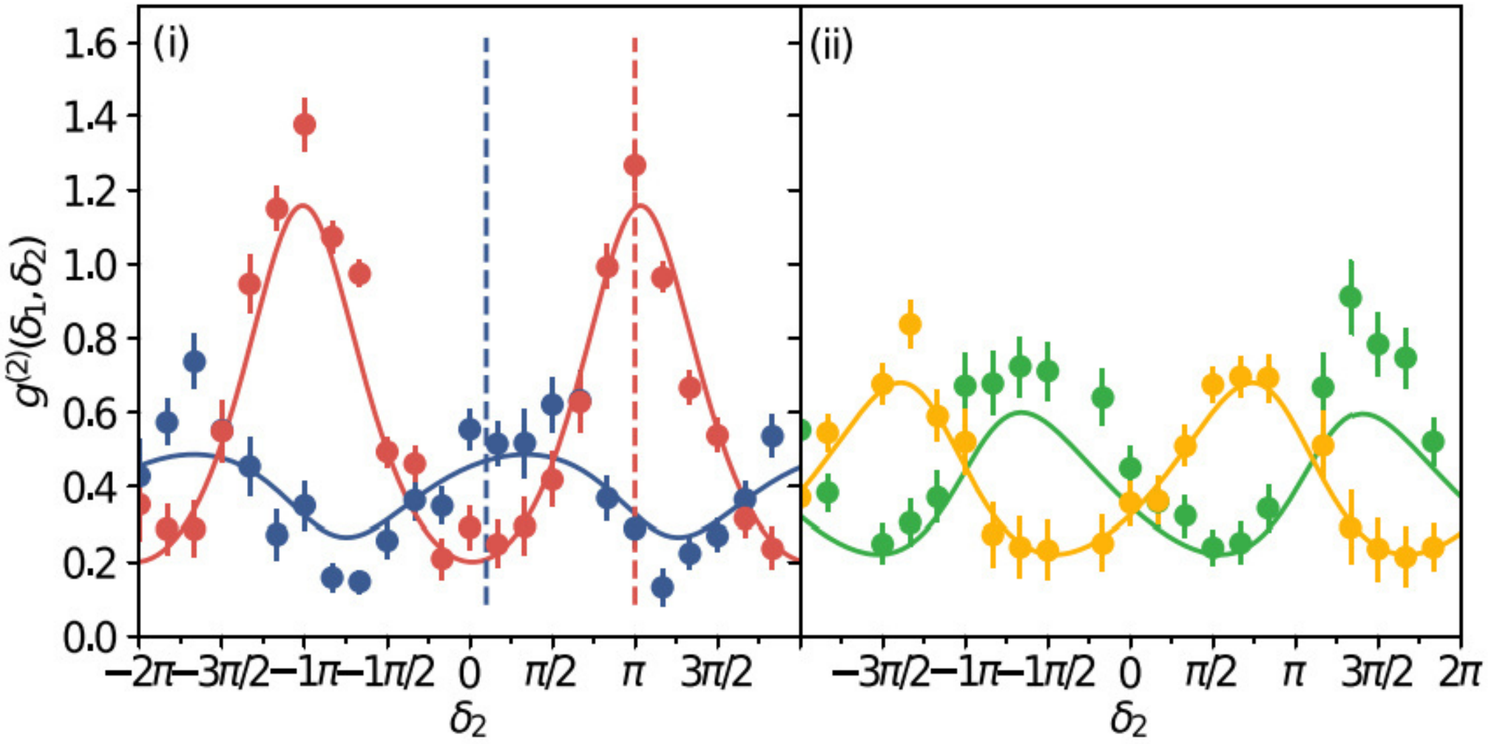
Two qubit level scheme and decay channels
[J.A. Mlynek et al., 2014]



PHOTON STATISTICS



Level scheme of the two-ion system in the Dicke basis[S. Richter et al., 2023]



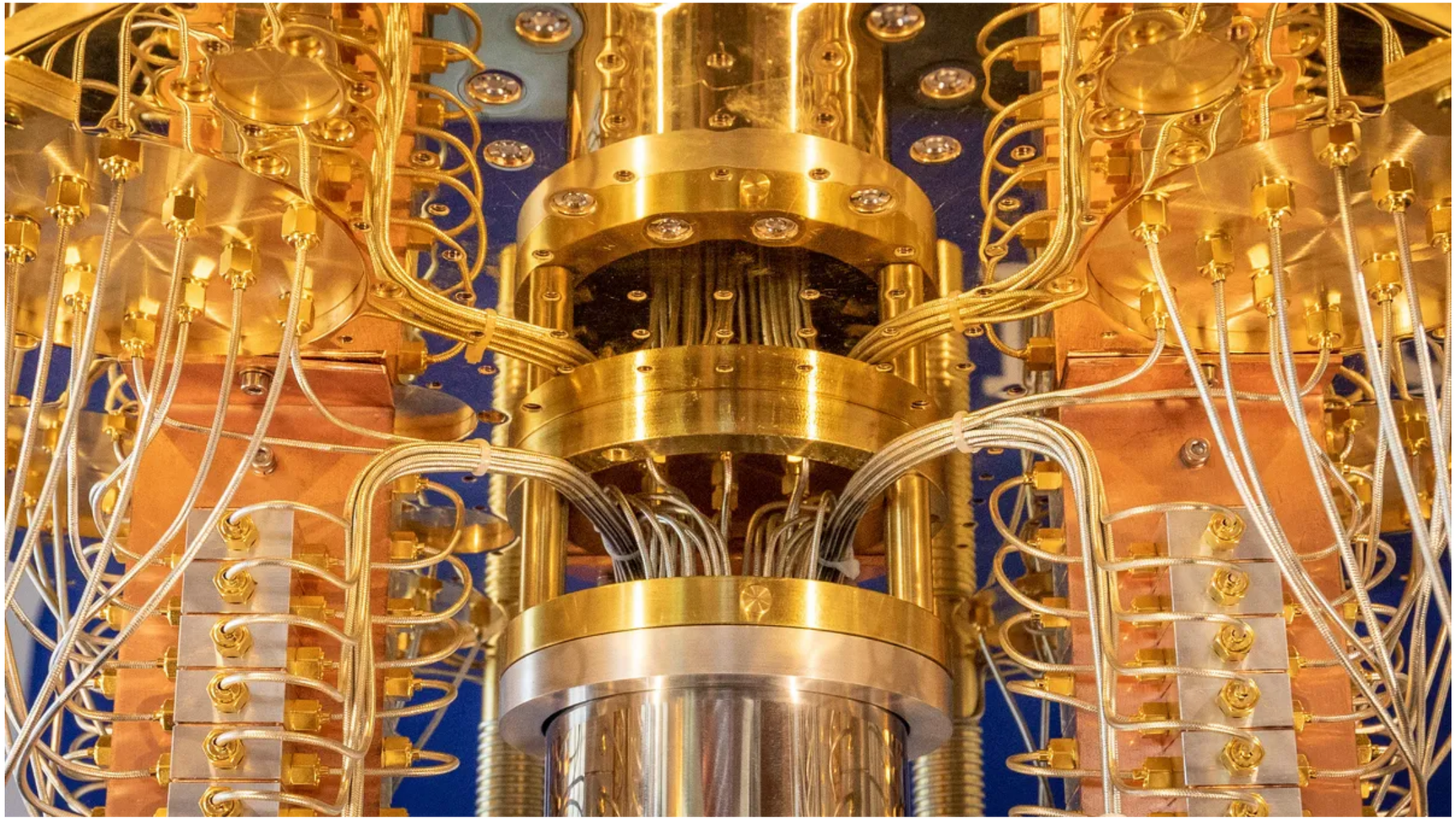
$|e\rangle \rightarrow |+\rangle \rightarrow |g\rangle$ generates a phase difference of 0.1π

$|e\rangle \rightarrow |-\rangle \rightarrow |g\rangle$ generates a phase difference of 1.0π

superradiance and sub-radiance are accompanied by photon anti-bunching and bunching, respectively.

TECHNOLOGICAL APPLICATIONS

Quantum Information Processing, Quantum Simulations, Precision Metrology and Fundamental Physics



CONCLUSIONS

The study of **super- and subradiant spontaneous emission** in systems involving **two ions** contributes to our understanding of fundamental quantum dynamics and the interplay between quantum emitters and the electromagnetic field. It sheds light on the **cooperative behavior** of quantum systems and the emergence of **collective effects**, providing valuable insights into the foundations of quantum mechanics.

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