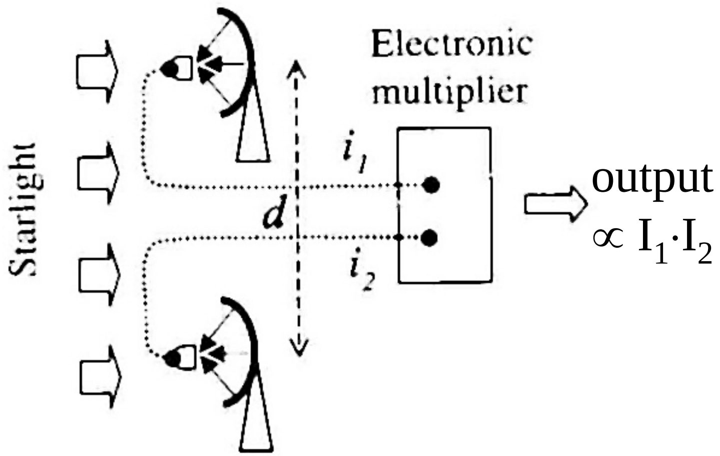
$g^{(2)}(\tau)$ in Astronomy

Stellar size measurements:

➢ Measurement $g^{(2)}(0)$ vs. detector separation

➢ Determines **spatial coherence**.

➢ Infer **source size**.



Hanbury Brown –Twiss Experiment

[figure adapted from, *Quantum Optics* by M. Fox]

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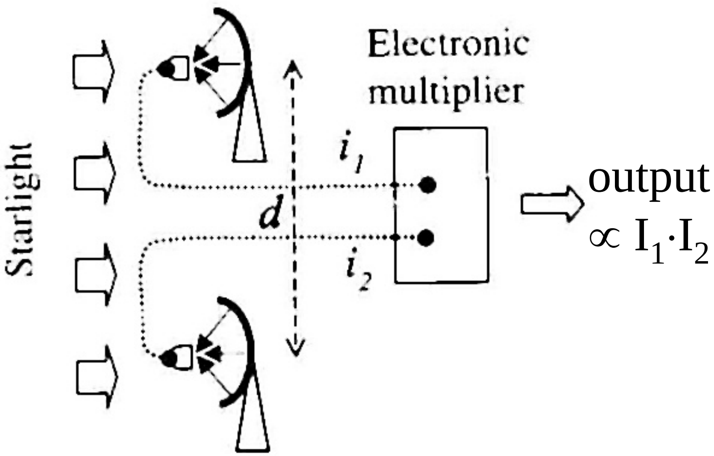

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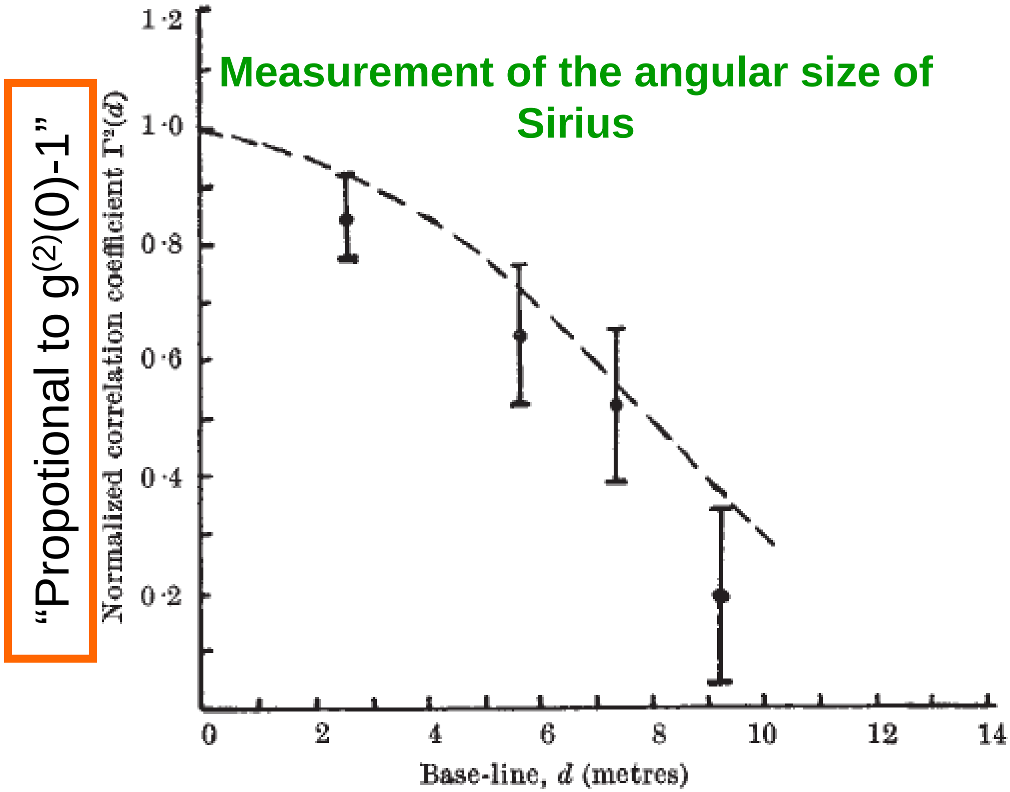

Fig. 2. Comparison between the values of the normalized correlation coefficient $\Gamma^2(d)$ observed from Sirius and the theoretical values for a star of angular diameter 0·0063". The errors shown are the probable errors of the observations

[figure adapted from, *Quantum Optics* by M. Fox]

[R. Hanbury Brown and R. Q. Twiss, Nature 178, 1046 (1956).]

$g^{(2)}(\tau)$ in Biophysics

Fluorescence Correlation Spectroscopy (FCS) measures $g^{(2)}(\tau)$ in biochemical systems.

FCS is used to determine:

- **diffusion** constants.
- Chemical **reaction rates**.
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- **Aggregation** of particles.
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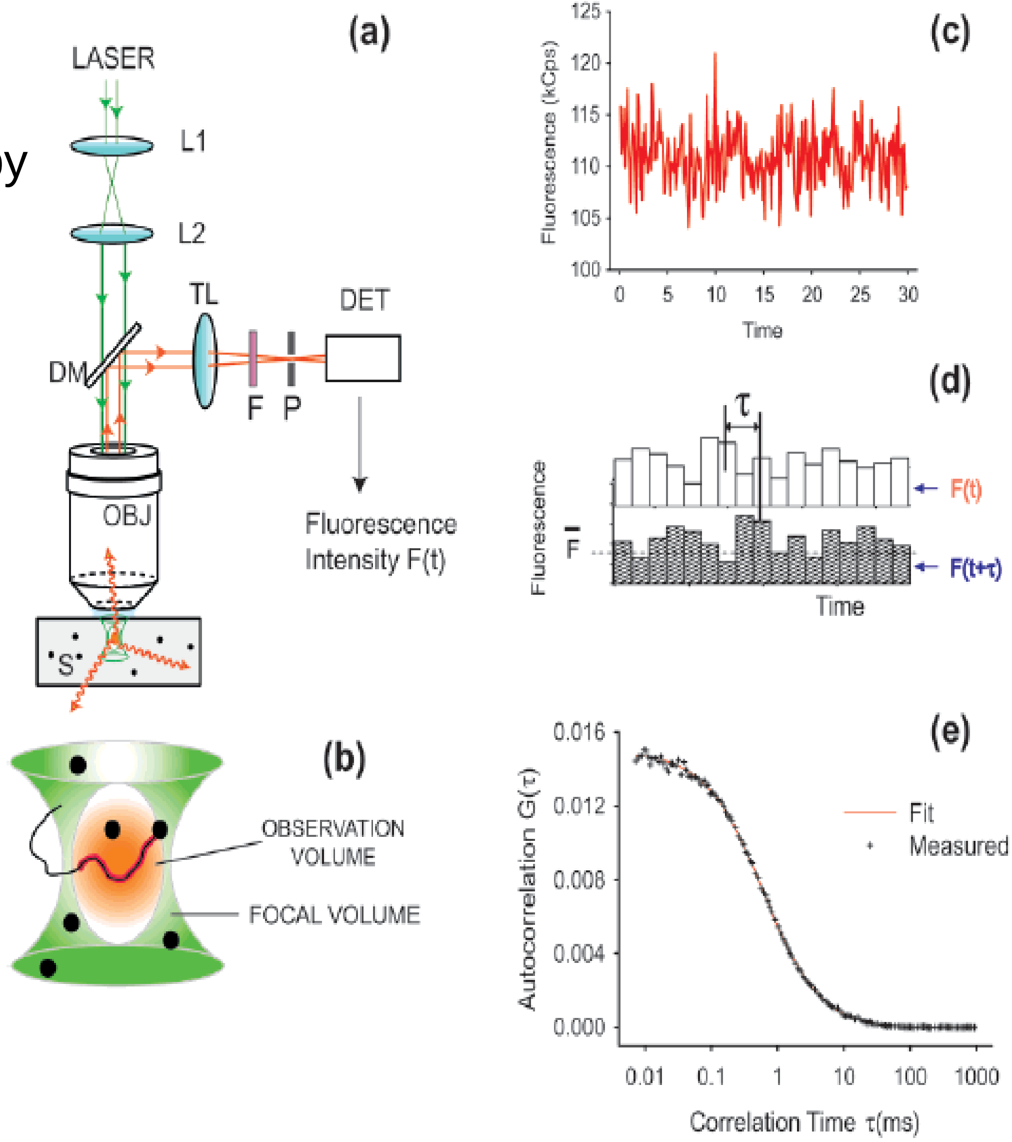

[Hess et al., Biochemistry 41, 697 (2002)]

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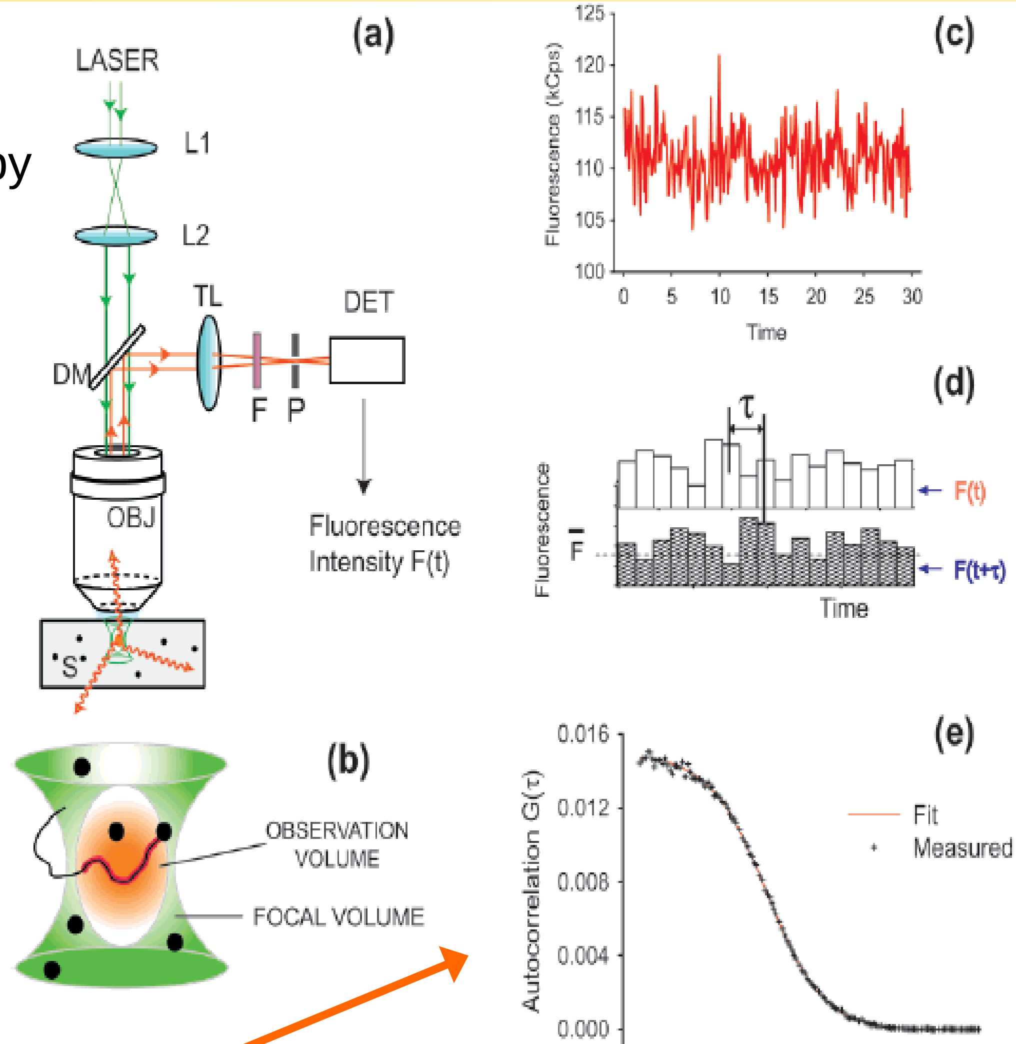


related to $g^{(2)}(\tau)$

[Hess et al., Biochemistry 41, 697 (2002)]

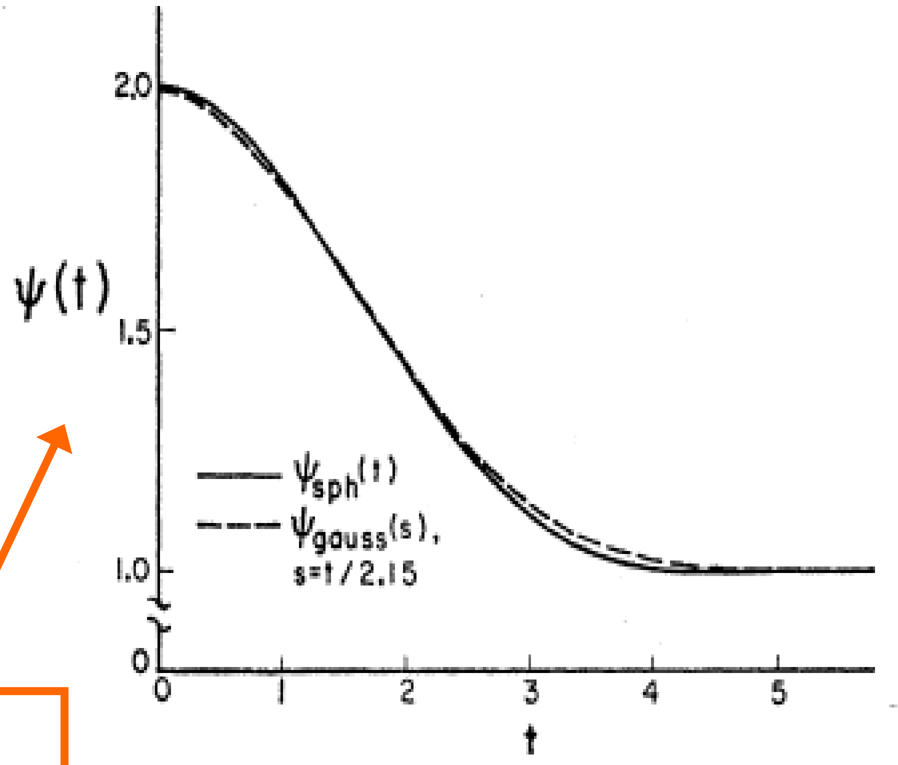
$g^{(2)}(\tau)$ in Nuclear Physics

Basic Idea:

- Use **Hanbury Brown – Twiss** to measure **spatial-temporal size** of interaction regions in nuclear collision reactions.

- **Correlation angles** of **Pions** emitted in a hadronization jet can be used to determine size of source.

$g^{(2)}(\tau)$



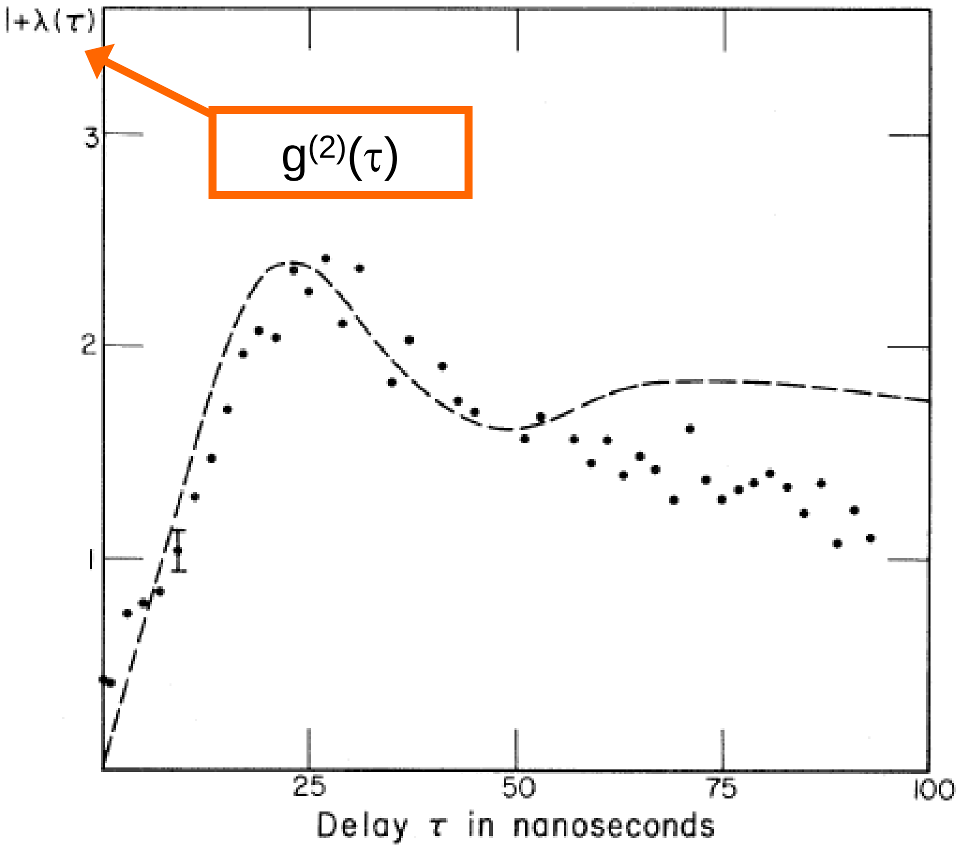
[figure adapted from G. Goldhaber et al., "Influence of Bose-Einstein Statistics on the Antiproton-Proton annihilation Process", Phys. Rev. 120, 300 (1960)]

$g^{(2)}(\tau)$ in Quantum Optics

In 1977, L. Mandel measured $g^{(2)}(\tau)$ for resonance fluorescence from Na atoms

According to Classical Physics:

$$g^{(2)}(0) \geq 1$$



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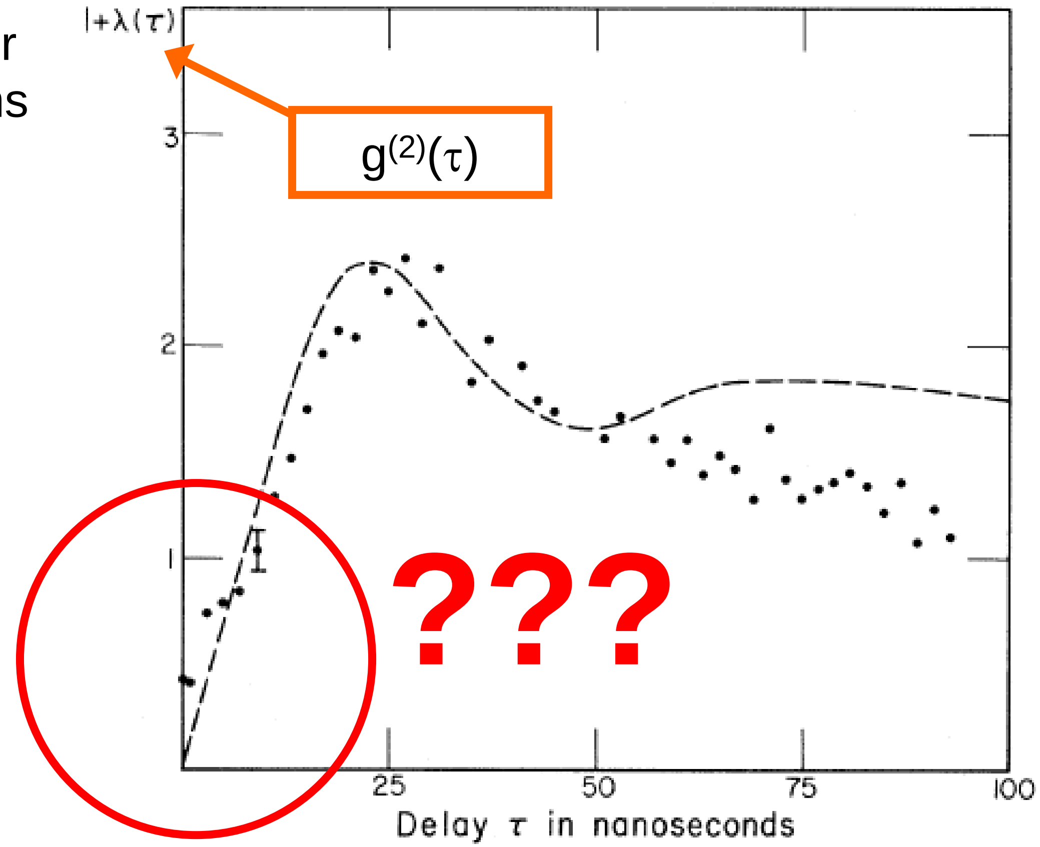
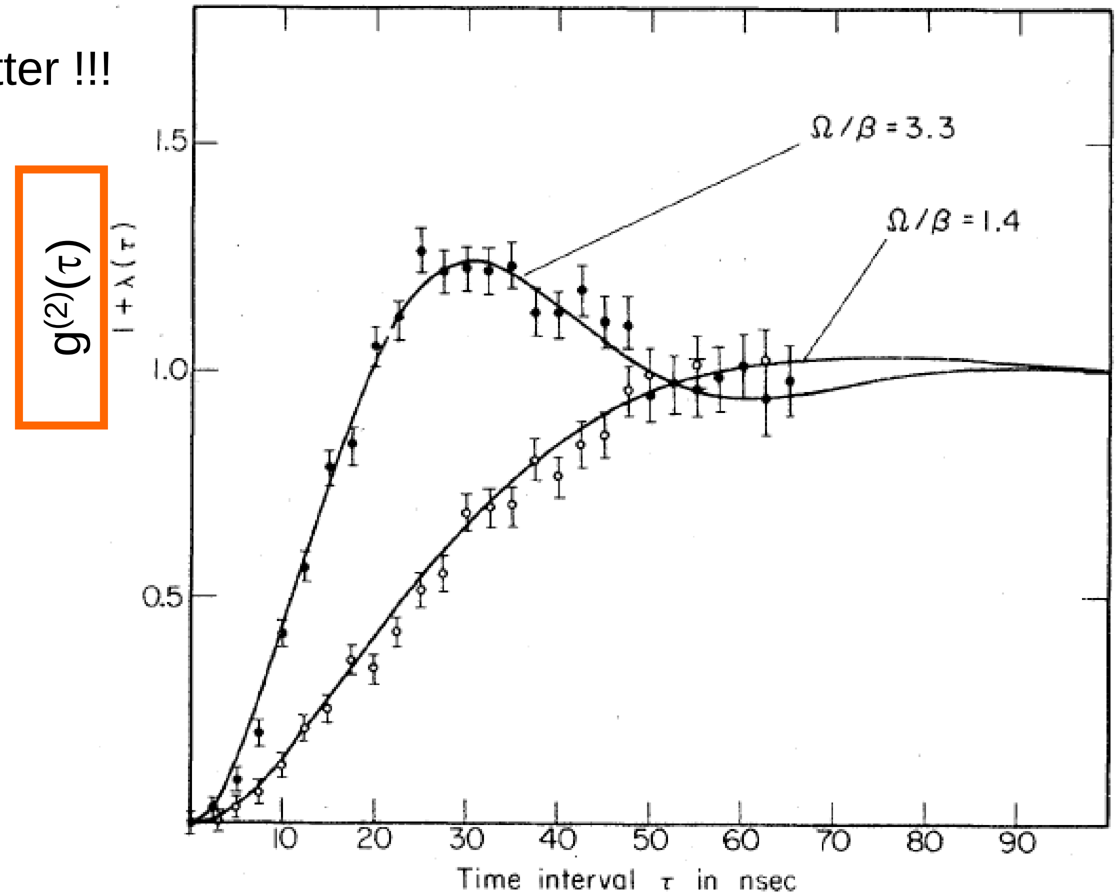


[Kimble et al., "Photon antibunching in resonance fluorescence", *Phys. Rev. Lett.* **39**, 691 (1977)]

$g^{(2)}(\tau)$ in Quantum Optics

In 1978, the data got even better !!!



[Dagenais and Mandel, Phys. Rev. A 18, 2217 (1978)]

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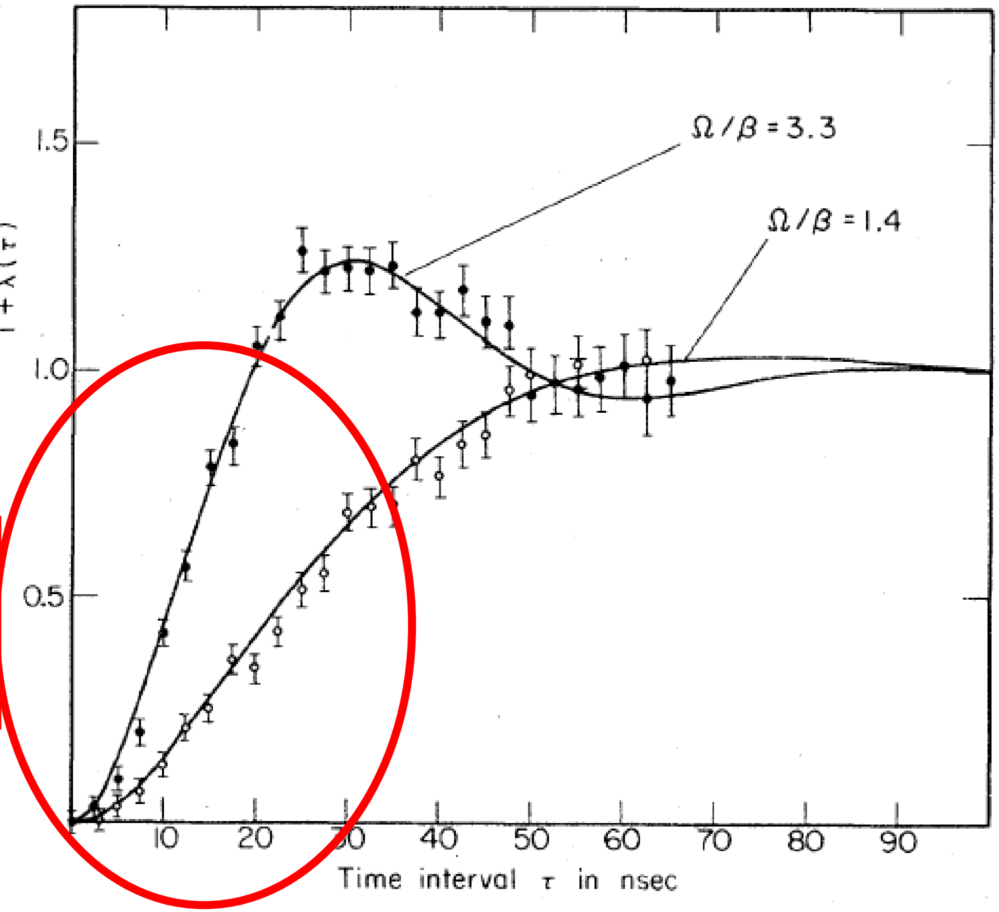

Non-classical light (quantum light), due to quantum aspects of fluorescence light.

[Dagenais and Mandel, Phys. Rev. A 18, 2217 (1978)]

2-level atoms

1. Definition and basics

2. Bloch sphere picture

3. Time-dependence

4. Interactions