

# MULTIPHOTONICS

$$E_{\pm}^k = k\omega_a - \frac{\Delta}{2} - i \frac{(2k-1)\gamma_a + \gamma_{\sigma}}{4} \pm \sqrt{(\sqrt{k}g)^2 + \left(\frac{\Delta}{2} - i \frac{\gamma_a - \gamma_{\sigma}}{4}\right)^2}$$

$$|\psi_N\rangle = \alpha_N |\psi_{N-2}\rangle + \beta_N \hat{t}_N^{\dagger} |\psi_{N-1}\rangle$$

$$E_{\text{nsf}} = \hbar \int_0^{\infty} \frac{d\xi}{2\pi} \text{Tr} \ln(1 - \mathcal{R}_1 e^{-\kappa L} \mathcal{R}_2 e^{-\kappa L})$$

$$H_P = e^{|X\rangle\langle X| \sum_{\mathbf{k}} (g_{\mathbf{k}}/\omega_{\mathbf{k}}) (b_{\mathbf{k}}^{\dagger} - b_{\mathbf{k}})} H e^{-|X\rangle\langle X| \sum_{\mathbf{k}} (g_{\mathbf{k}}/\omega_{\mathbf{k}}) (b_{\mathbf{k}}^{\dagger} - b_{\mathbf{k}})}$$

$$\partial_t \rho = i[\rho, \Delta \sigma^{\dagger} \sigma + \Omega(\sigma + \sigma^{\dagger})] + (\gamma_{\sigma}/2) \mathcal{L}_{\sigma} \rho$$

$$|\psi\rangle_t = \sqrt{p_0} |0\rangle_t |g\rangle_t + \sqrt{p_1} e^{i2\pi\nu t} \frac{|0\rangle_t |e\rangle_t + |1\rangle_t |g\rangle_t}{\sqrt{2}}$$

$$\hat{H} = \hbar g (\hat{a}^{\dagger} \hat{\sigma}_- + \hat{a} \hat{\sigma}_+) \quad g^{(2)}(\tau) = 1 + \begin{cases} \sqrt{2} (1-p) \frac{\tilde{\gamma}_2}{\gamma_1} \exp(\tilde{\gamma}_2 \tau) & \text{if } \tau < 0 \\ p \frac{\gamma_2}{\gamma_1} \exp(-\gamma_2 \tau) & \text{if } \tau > 0 \end{cases}$$

$$S(\omega) = \text{Re} \left[ \int_{-\infty}^{\infty} dt \int_{-\infty}^{\infty} d\tau G^{(1)}(t, \tau) e^{-i\omega\tau} \right] \quad \partial_t \rho = i[\rho, H]$$

$$\partial_t \mathbf{w}_{[\mu_1\nu_1, \mu_2\nu_2, \mu_3\nu_3]} = \left\{ M + \mathbb{I} \left[ (\mu_1 - \nu_1) i \omega_1 - (\mu_1 + \nu_1) \frac{\Gamma_1}{2} + (\mu_2 - \nu_2) i \omega_2 - (\mu_2 + \nu_2) \frac{\Gamma_2}{2} + (\mu_3 - \nu_3) i \omega_3 - (\mu_3 + \nu_3) \frac{\Gamma_3}{2} \right] \right\} \mathbf{w}_{[\mu_1\nu_1, \mu_2\nu_2, \mu_3\nu_3]} + \mu_1 (i\varepsilon_1 T_+) \mathbf{w}_{[0\nu_1, \mu_2\nu_2, \mu_3\nu_3]} + \nu_1 (-i\varepsilon_1 T_-) \mathbf{w}_{[\mu_1 0, \mu_2\nu_2, \mu_3\nu_3]} + \mu_2 (i\varepsilon_2 T_+) \mathbf{w}_{[\mu_1\nu_1, 0\nu_2, \mu_3\nu_3]} + \nu_2 (-i\varepsilon_2 T_-) \mathbf{w}_{[\mu_1\nu_1, \mu_2 0, \mu_3\nu_3]} + \mu_3 (i\varepsilon_3 T_+) \mathbf{w}_{[\mu_1\nu_1, \mu_2\nu_2, 0\nu_3]} + \nu_3 (-i\varepsilon_3 T_-) \mathbf{w}_{[\mu_1\nu_1, \mu_2\nu_2, \mu_3 0]}$$

$$g_{\Gamma_1 \dots \Gamma_N}^{(N)}(\omega_1, T_1; \dots; \omega_N, T_N) = \lim_{\varepsilon \rightarrow 0} \frac{\langle :n_1(T_1) \dots n_N(T_N): \rangle_{\mathcal{T}}}{\langle n_1(T_1) \rangle \dots \langle n_N(T_N) \rangle}$$

$$\tilde{\rho}_{01}^{(t_0, \infty)} \approx -\frac{|T_-|}{\text{Re } \lambda_+} |\rho_{GX}(t_0)| \quad H = \hbar \omega (a^{\dagger} a + 1/2)$$

$$g_{\Gamma}^{(2)}(\varpi_1, \varpi_2) = \frac{(\varpi_1^2 + \varpi_1 + \varpi_2^2 + \varpi_2)^2}{(\varpi_1 + \varpi_2)^2 (\varpi_1 + 1)^2 (\varpi_2 + 1)^2}$$

$$\mathbb{P} = \text{Tr}_{b_{XX \rightarrow X}} [\rho^2] = \frac{\gamma_{XX}}{\gamma_{XX} + \gamma_X}$$

$$\text{Pr}_P(m, t) = \frac{\text{Tr} (\hat{M}_m \rho(t) \hat{M}_m^{\dagger} E(t))}{\sum_{m'} \text{Tr} (\hat{M}_{m'} \rho(t) \hat{M}_{m'}^{\dagger} E(t))}$$

$$\Omega_R = \sqrt{\Omega_0^2 + \Delta^2}$$

$$A_{\{k\}} = \prod_{j=1}^N \frac{\sqrt{\gamma_j}}{i(j\omega_0 - \sum_{i=1}^j \omega_{k_i}) - \frac{1}{2}\gamma_j} + \{k_i \leftrightarrow k_j\}$$

$$g_N^{(2)}(\tau) = \frac{\langle a^{\dagger N}(0) a^{\dagger N}(\tau) a^N(\tau) a^N(0) \rangle}{\langle (a^{\dagger N} a^N)(0) \rangle \langle (a^{\dagger N} a^N)(\tau) \rangle} \quad \eta_{\text{fiber}}(\lambda) \approx \theta \sigma(\lambda) \cdot \frac{2\pi R L}{A_{\text{eff}}(\lambda)}$$

$$g^{(2)}(\tau) = (1 + \gamma t_G) e^{-\gamma(|\tau| - t_G)} \sum_{n=0}^{\infty} \frac{[\gamma(|\tau| - (n+1)t_G) e^{\gamma t_G}]^n}{n!} \mathbf{1}_{[(n+1)t_G, \infty[}(|\tau|)$$

# MULTIPHOTONICS

The first **MULTIPHOTONICS** meeting will take place in Garching bei München on 4–5 July (2024) with the support of Elena del Valle's Hans Fisher Fellowship of the IAS at TUM. This is organised by the HF focused group *Novel quantum-light sources*: Kai Müller, Sang Kyu Kim and Elena del Valle. Scientific secretaries: Sang Kyu Kim and Eduardo Zubizarreta Casalengua.

## Invited speakers and participants

1. Ahsan Nazir - University of Manchester
2. Alejandro González Tudela - IFF-CSIC Madrid
3. Andreas Muller - University of South Florida, USA
4. Arno Rauschenbeutel - Humboldt University in Berlin
5. Carlos Antón Solanas - Universidad Autónoma de Madrid
6. Carlos Sánchez Muñoz - IFF-CSIC Madrid
7. Doris Reiter - Technische Universität Dortmund
8. Eduardo Zubizarreta Casalengua - Technische Universität München
9. Fabrice Laussy - ICMC-CSIC Madrid
10. Gerhard Rempe - Max Planck Institute of Quantum Optics, Munich
11. Jake Iles-Smith - University of Manchester
12. Klaus D. Jöns - Paderborn University
13. Klaus Mølmer - Københavns Universitet
14. Serge Reynaud - Laboratoire Kastler Brossel, Paris
15. Zhiliang Yuan - Academy of Quantum Information Sciences, Beijing

PhD speakers:

16. Sana Khalid - University of Wolverhampton
17. Sang Kyu Kim - Technische Universität München
18. Paul Hagen - Bayreuth University
19. Santiago Bermúdez Feijóo - Paderborn University
20. Mateusz Salamon - University of Manchester

Kai Müller's group at Walter Schottky Institut and Technische Universität München:

21. Kai Müller
22. Friedrich Sbresny
23. Carolin Calcagno

Elena del Valle's group at Universidad Autónoma de Madrid:

24. Elena del Valle
25. Miguel Ángel Palomo Marcos

## Program

Talks are 40 min long: 25 to 30 min presentation + 10 to 15 min questions & discussion

## Wednesday, 3.7.2024

Arrival of participants and night 1 at the hotel.

## Thursday, 4.7.2024

09:00 - 09:20 Welcome reception (& coffee) & Workshop opening by Elena del Valle

### **SESSION 1:** Chairing Elena del Valle

09:20 - 10:00 -- Gerhard Rempe: *Efficient generation of high-fidelity multi-photon graph-state entanglement*

10:00 - 10:40 -- Doris Reiter: *Many and few photon SUPER: Theory of inverting a quantum emitter with off-resonant light in the semiclassical and quantum picture*

10:40 - 11:20 -- Klaus Mølmer: *Jaynes-Cummings Interactions Keeping Up With Light That Moves*

11:20 - 12:00 -- Fabrice Laussy: *10 years of the bundler*

12:00 - 13:20 **Lunch #1** (1h20)

### **SESSION 2:** Chairing Fabrice Laussy

13:20 - 14:00 -- Elena del Valle: *Multiple and colorful photons*

14:00 - 14:40 -- Andreas Muller: *Second and third order frequency-resolved photon correlations from a semiconductor quantum dot in resonance fluorescence using tunable filters*

14:40 - 15:20 -- Ahsan Nazir: *Photon statistics of spectrally-filtered resonance fluorescence*

15:20 - 16:00 -- Zhiliang Yuan: *Intuitive spontaneous emission model for resonance fluorescence from deep Heitler to high Mollow excitation regime*

16:00 - 16:30 **Coffee break** (30min)

### **SESSION 3:** PhD speakers, chairing Kai Müller (15 min presentation + 5 questions)

16:30 - 16:50 -- Sang Kyu: *Experimental attempts to discover hidden photons in resonance fluorescence*

16:50 - 17:10 -- Paul Hagen: *Why phonons increase photon number coherence of a QD-cavity system excited by a resonant laser pulse*

17:10 - 17:30 -- Santiago Bermúdez Feijóo: *Entanglement in the Mollow regime of the photons coming from the satellite peaks driven by an off resonant source*

17:30 - 17:50 -- Sana Khalid: *A perfect single photon source*

17:50 - 18:10 -- Mateusz Salamon: *Understanding phonon effects in filtered resonance fluorescence of quantum dot single-photon sources*

18:10 - 18:30 -- Miguel Ángel Palomo Marcos: *Heralding single photons in detuned resonance fluorescence*

18:40 Final round table during **dinner**.

20:00 Drinks, night 2 at the hotel.

## Friday, 5.7.2024

09:15 - 09:20 Welcome back

### **SESSION 4:** Chairing Gerhard Rempe

09:20 - 10:00 -- Serge Reynaud: *The resonance fluorescence cascade of a laser-excited two-level atom*

10:00 - 10:40 -- Arno Rauschenbeutel: *Photon-photon correlations in superradiant bursts of light from cascaded quantum emitters*

10:40 - 11:20 -- Eduardo Zubizarreta Casalengua: *Squeezing and stretching photon statistics (with coherent light)*

11:20 - 12:00 -- Carlos Antón Solanas: *Resonant driving of artificial atoms to generate superposition, time-entanglement and energy-time-entanglement encoded in the photon number basis*

12:00 - 13:20 -- Workshop **group photo** and **Lunch #2** (1h20)

### **SESSION 5:** Chairing Klaus Mølmer

13:20 - 14:00 -- Alejandro González Tudela: *Strategies for multi-photon generation based on collective and programmable light-matter interactions*

14:00 - 14:40 -- Klaus D. Jöns: *Optical Coherent Control of Droplet-etched GaAs Quantum Dots and the Reappearance of Rabi Oscillations*

14:40 - 15:20 -- Carlos Sánchez Muñoz: *Strong driving of quantum emitters: routes towards entanglement and multiphoton generation*

15:20 - 16:00 -- Kai Müller: *Dynamics of Single-photon and multi-photon generation from semiconductor quantum dots*

16:00 - 16:30 Final discussions with coffee & Workshop closing by Kai Müller

16:30 Participants leave

### **Venue:** [Institute for Advanced Study](#)

We will be meeting at the auditorium of the IAS building ground floor at Lichtenbergstraße 2 a, 85748 Garching ([location](#))

### **Hotel**

All participants have a room booked with breakfast for both nights at the Hotel Hoyacker Hof: Freisinger Landstraße 9a, 85748 Garching  
Tel: 089/3269900, e-mail: [info@hoyackerhof.de](mailto:info@hoyackerhof.de), [web](#)

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