Next Nearest Neighbour Coupling in Polariton Condensates

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INTRODUCTION

Polariton condensates is a promising tool to engineer and simulate complex Hamiltonians [1]. Conventionally nearest-neighbour (NN) coupling dominates over next-nearest-neighbour (NNN) coupling making polariton networks inherently planar in a graph topology sense. In this study [2] we experimentally demonstrate that the NNN coupling can be made stronger than NN coupling in ballistic spin-orbit coupled polariton condensates. From complexity theory enabling NNN interactions of comparable to NN strength make even simplest 1D chain an NP-problem, opening a new horizon for investigation of polariton simulators as a platform for addressing NP-problems.

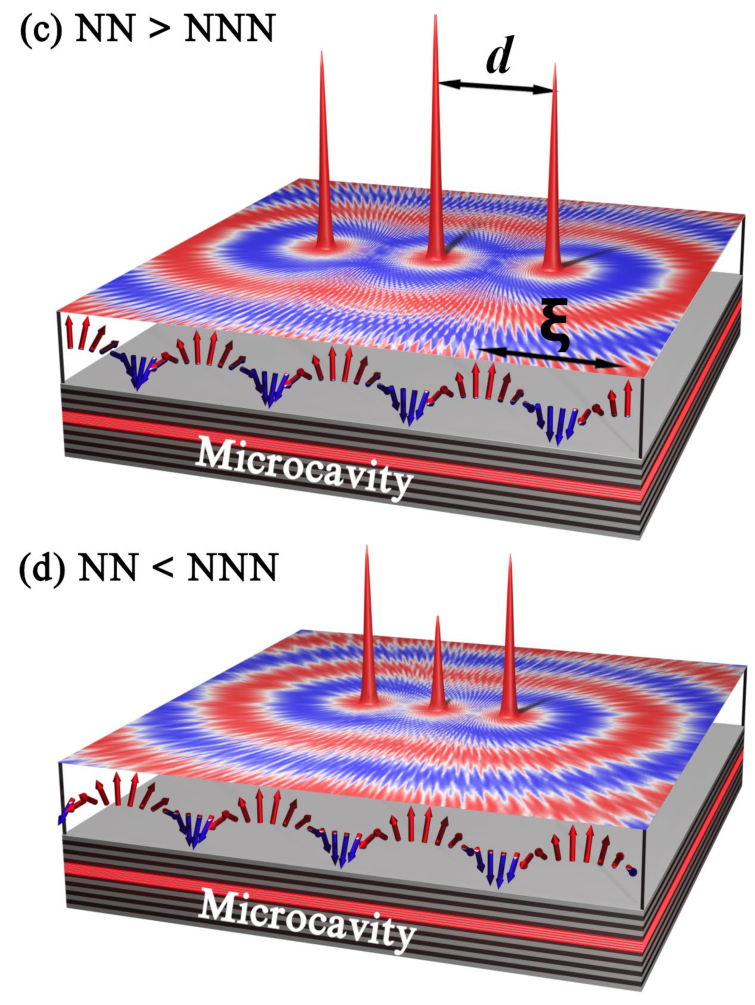

Fig 1. Example of the hierarchy inversion in triad.

EXPERIMENTAL SETUP

- AlGaAs microcavity with GaAs QWs placed in cold finger cryostat at 6K.
- Measured TE-TM splitting is $\approx 0.2\ meV$ at $k = 3\mu m^{-1}$.
- Nonresonant CW laser at 754 nm and right circularly polarization (σ^+).
- Woolaston prism and quarter waveplate were used for S_z measurements.

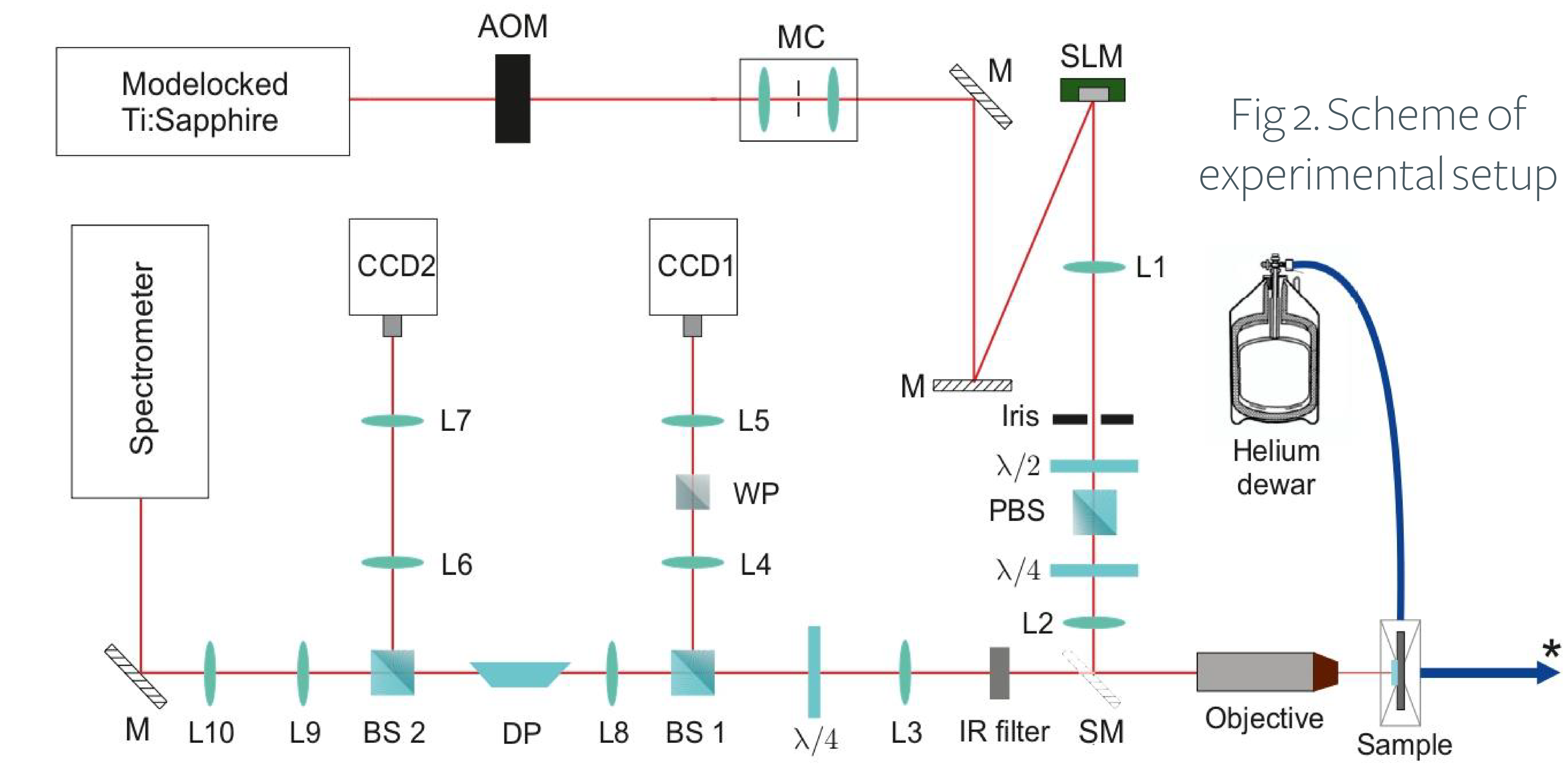

Fig 2. Scheme of experimental setup

THEORY: DYAD

Effect of nearest-neighbours spin-screening arise from the combination of two factors:

- Spin precession from TE-TM splitting with period: $\xi = 2\pi/\Delta_k$
- Weak cross-spin polariton interactions:

$$H_\pm = .. + \alpha_1 |\psi_\pm| + \alpha_2 |\psi_\mp| + ..$$

$$\alpha_1 \gg \alpha_2$$

Condensates separated by distance $d \approx \xi/2$ will "not see" each other, leaving NNN interaction dominant and decreasing total intensity and coupling strength.

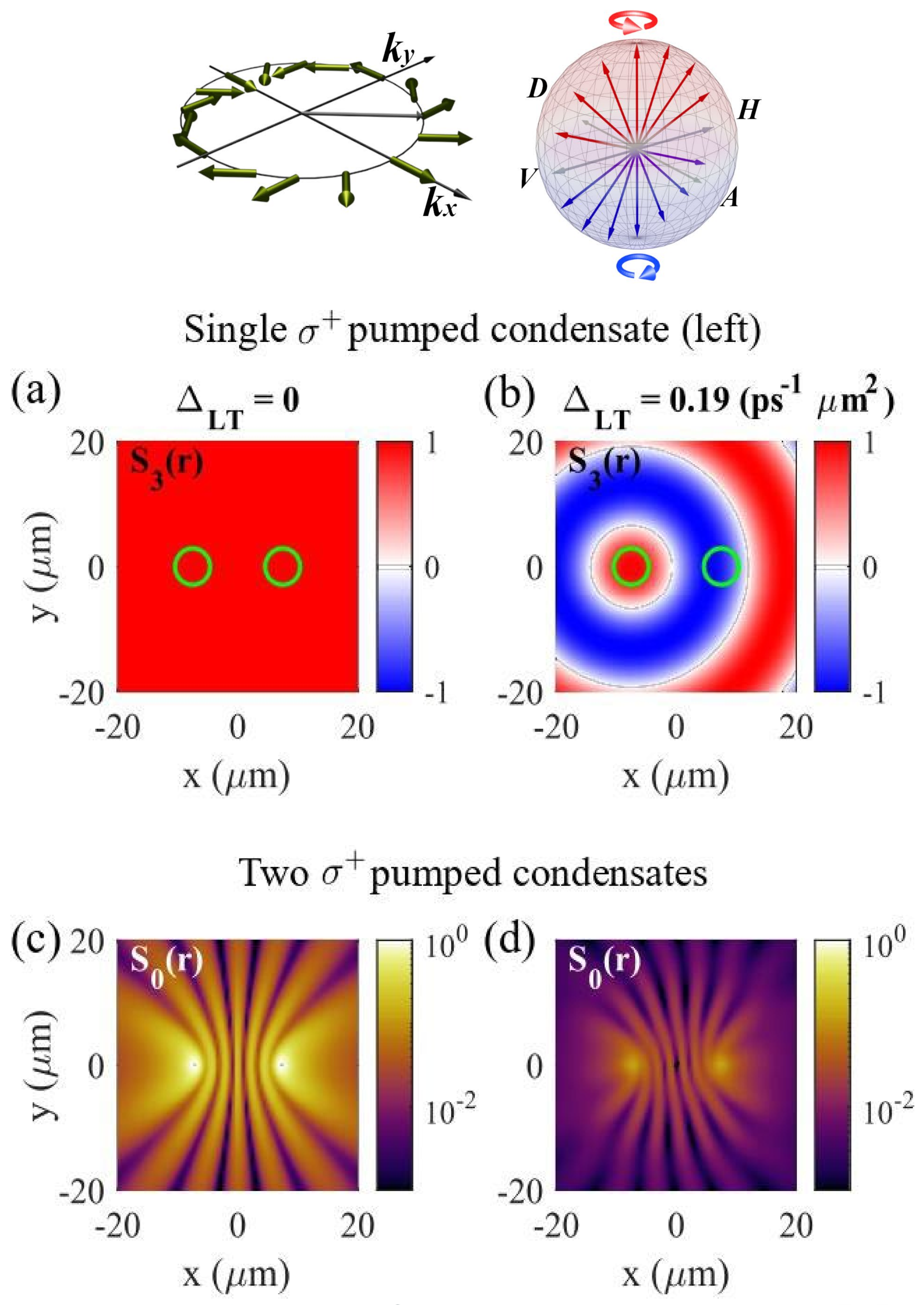

Fig 3. Simulations of spin-screening in dyad [3].

EXPERIMENT: DYAD

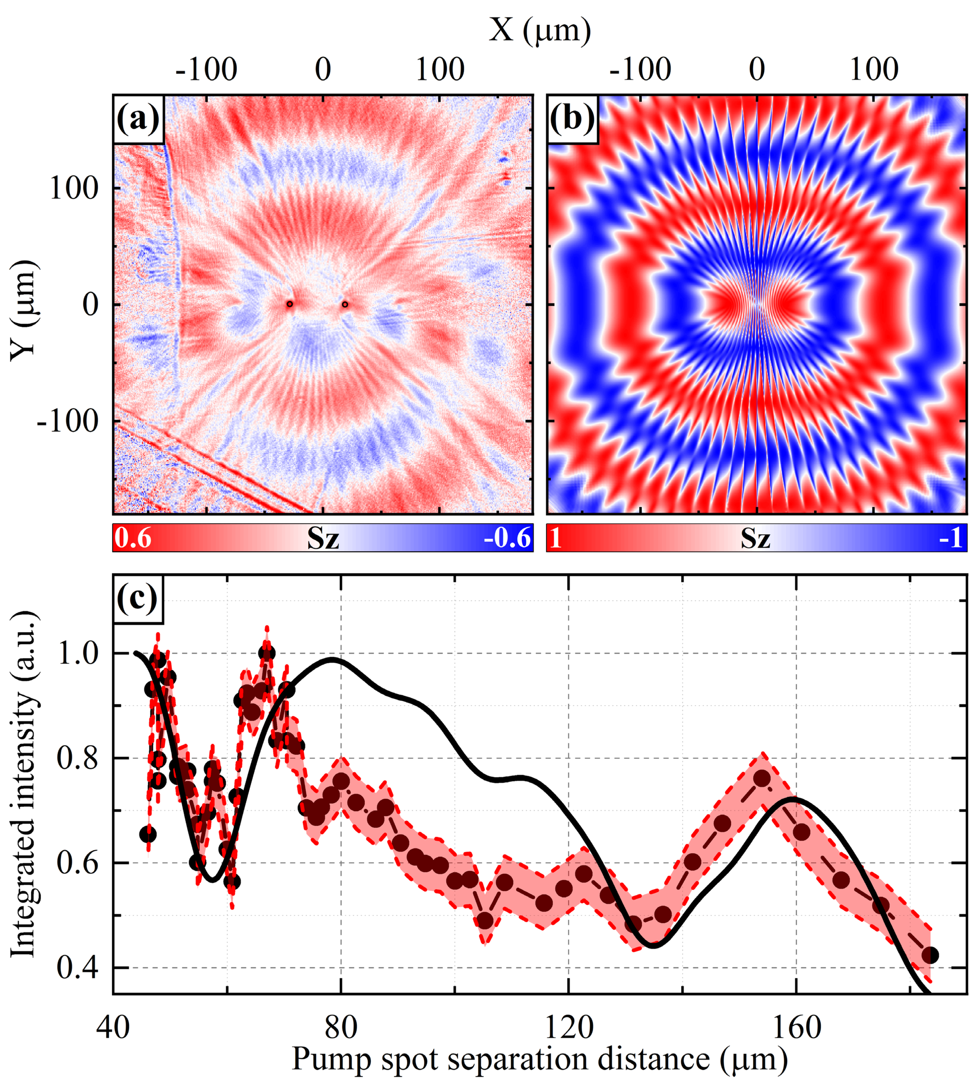

Fig 4. Experimental and simulated condensate S_z and total intensities in dyad.

In a system of two condensates (dyad) we were able to observe the **whole cycle of suppression and restoration of NN interaction.**

Polariton dephasing in experiment is a reason for reduced amplitude of S_z precession.

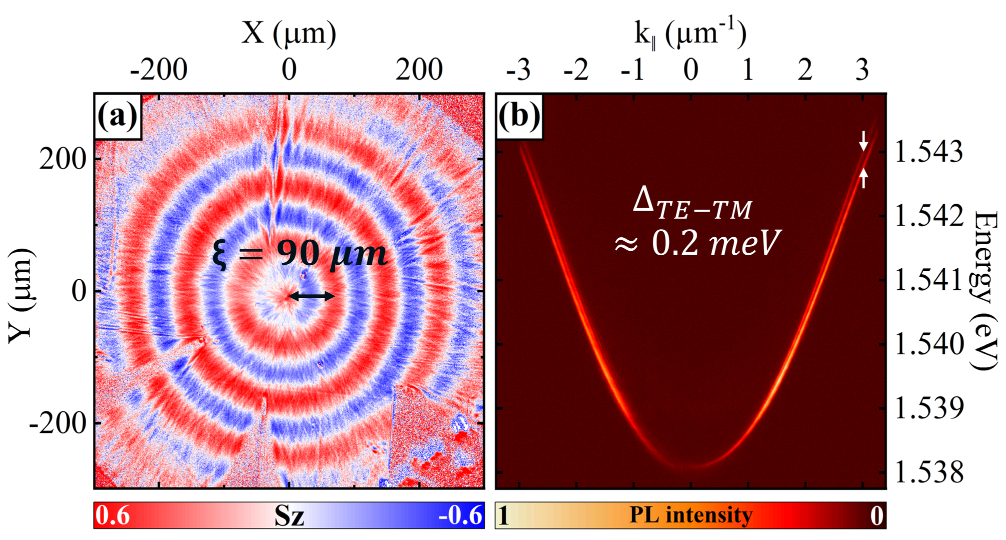

Fig 5. Experimental single condensate S_z and dispersion.

THEORY: TRIAD

Suppression of the central spot in the chain of three condensates (triad) pumped equally with right circular polarisation, when their separation distance $d \approx \xi/2$, see is expected.

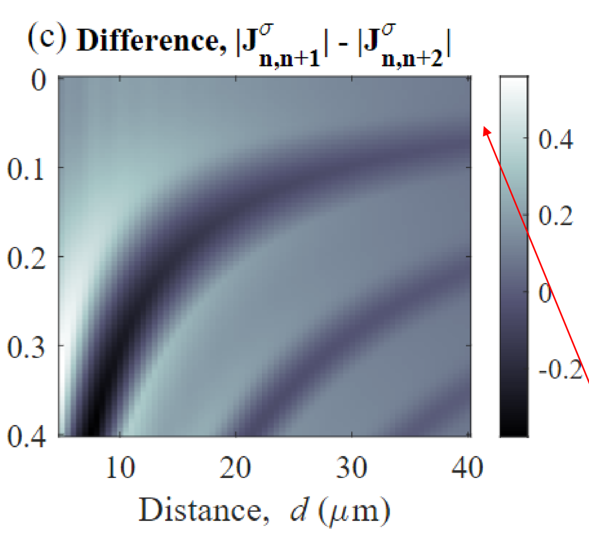

Fig 6. Simulations of interaction strength of NN and NNN in triad [3].

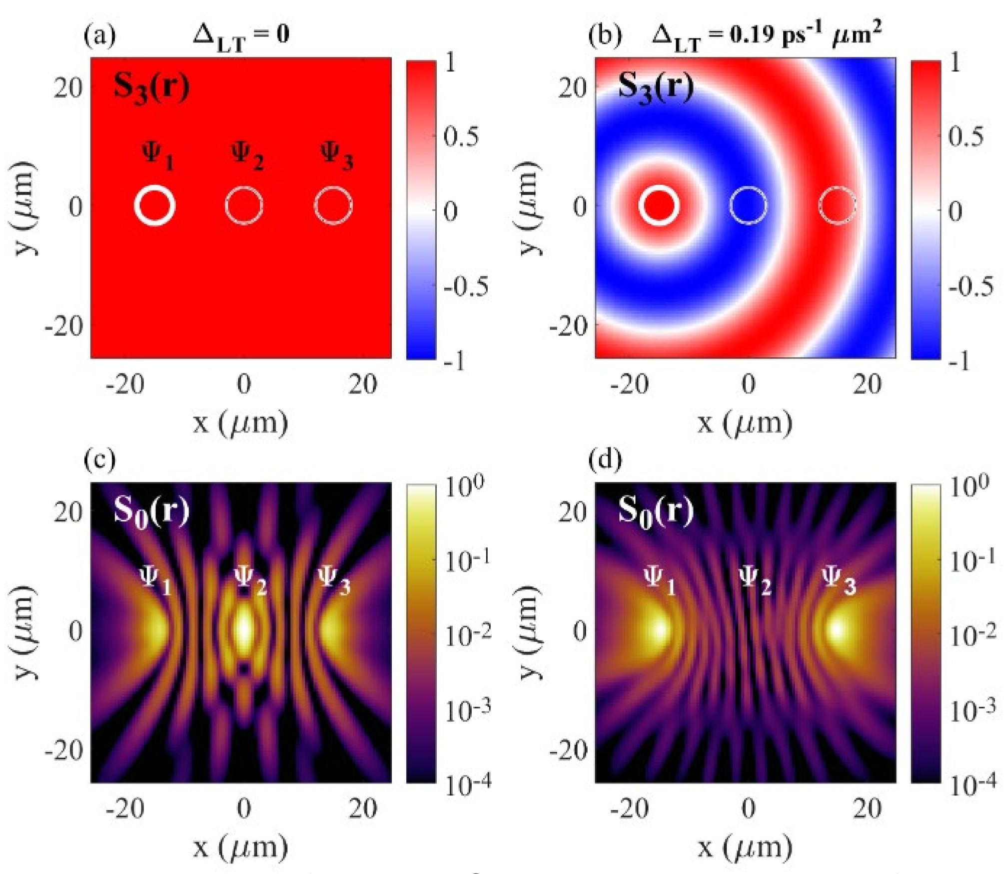

Fig 7. Simulations of spin-screening in triad [3].

Value of TE-TM splitting in the experiment is **4 times less**, than in previous simulations [3], which explains **less pronounced effect** and its **high separation requirement ~50 μm.**

RESULTS: TRIAD

Suppression of the central spot in triad observed at $d \approx 52\ \mu m$. Interaction is restored at $d \approx \xi$.

Stripes in S_z of dyad and triad is a consequence of differently oriented chirality of spin-up and spin-down components.

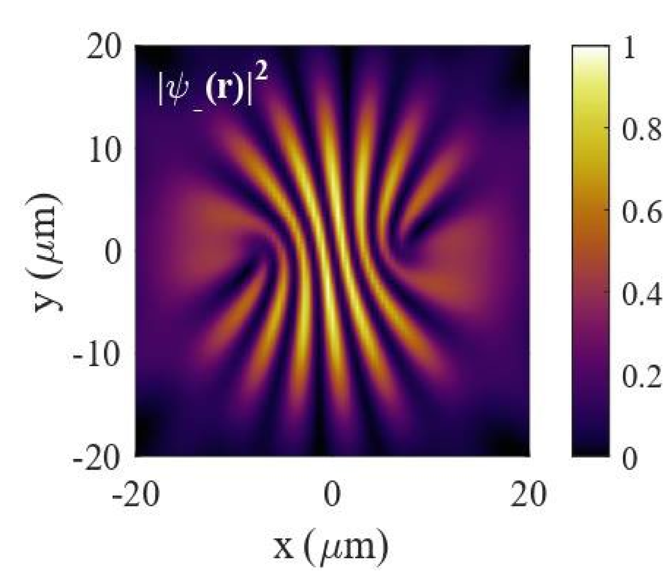

Fig 8. Simulated spin-up density in dyad [3].

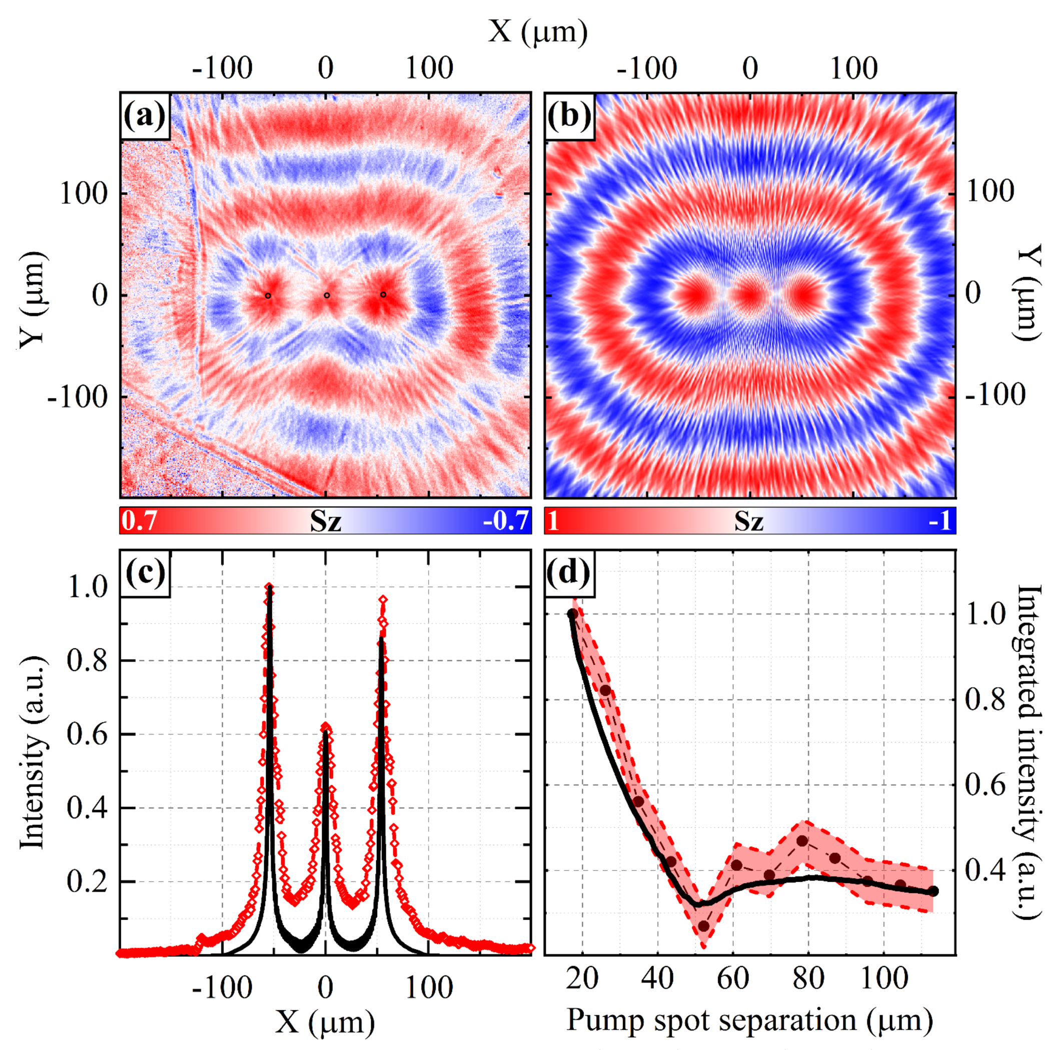

Fig 9. Experimental and simulated condensate S_z and densities in triad.

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