Supplementary online material

RATE-EQUATIONS

Additional to Eq. (1) in the main text, the remaining equations of motion read [1]:

$$\begin{aligned}
\frac{\mathrm{d}}{\mathrm{dt}}p_\omega &= -\frac{1}{2}\left(\gamma_\mathrm{d}+\gamma_\mathrm{p}+2\gamma\right)p_\omega + i\frac{\delta_\omega}{\hbar}p_\omega + iG\mathcal{E}\left(x_\omega - g_\omega\right)\\
\frac{\mathrm{d}}{\mathrm{dt}}g_\omega &= -\gamma_\mathrm{p}g_\omega + \gamma_\mathrm{d}x_\omega - i\left(G^*\mathcal{E}^*p_\omega - G\mathcal{E}p_\omega^*\right)\\
\frac{\mathrm{d}}{\mathrm{dt}}x_\omega &= -\gamma_\mathrm{d}x_\omega + \gamma_\mathrm{r}y_\omega + i\left(G^*\mathcal{E}^*p_\omega - G\mathcal{E}p_\omega^*\right)\\
\frac{\mathrm{d}}{\mathrm{dt}}y_\omega &= -\gamma_\mathrm{r}y_\omega + \gamma_\mathrm{p}g_\omega\,,
\end{aligned}$$

where g_ω, x_ω and y_ω are the occupation numbers of the three electronic states, p_ω is the microscopic polarization and $\delta_\omega(t) = \hbar\omega_c - [\hbar\omega_x(t) + D\eta(t)]$ is the detuning between the cavity mode and the considered exciton transition. The other quantities are explained in the main text.

EXPERIMENTAL SETUP

The studied microcavity is formed by two distributed Bragg reflectors (DBRs) made from alternating $\lambda/4$ GaAs/AlAs layers and a λ-cavity GaAs layer sandwiched in between. In the bottom and top DBR there are 27 and 23 periods, respectively, which makes the top DBR the output mirror. The central layer defines the resonant wavelength. Because it is wedge shaped, the cavity mode varies for different spots on the sample. It can be chosen from 1.33 eV to 1.37 eV and has a width of about 1.2 meV. In the center of the cavity, a layer of self-assembled $In_{0.3}Ga_{0.7}As$ QDs with a density of $\sim 10^{10}\,\mathrm{cm}^{-2}$ is positioned, which is optically excited by a continuous wave 532 nm laser high above the band gap. To obtain the distribution of the electronic transitions, its photoluminescence was measured from the side of the sample, such that it is unfiltered by the microcavity. The center of the Gaussian distribution is found to be at 1.351 eV and has a full width at half maximum of 11 meV, which is almost ten times larger than the width of the cavity mode.

The acoustic pulses are generated by an amplified laser with a wavelength of 800 nm, a pulse duration of 200 fs and a repetition rate of 100 kHz, which is focused onto an 100 nm thick aluminum film to a spot with a diameter of about 150 m. To create a sufficient strain amplitude, power densities of about 10 $\mathrm{mJ/cm^2}$ are required. Moreover, the sample is placed inside a bath cryostat, where its temperature is kept at 8 K by the surrounding helium atmosphere, to prevent a strong attenuation of the acoustic pulse.

INPUT-OUTPUT CURVES

The measured and simulated input-output curves of the laser for the three different detunings are shown in Figs. 1 (a) and 1 (b), respectively. In the experimental curves one can see that the threshold region is extended and for a lower detuning the threshold also decreases. We also observe a steeper slope for the positive detuning of $\Delta(0)$=14.5 meV, which might be connected with higher exciton levels coupling to the resonator mode. Moreover, the output enhancement when crossing the laser threshold is significantly lower for the case of the large negative detuning $\Delta(0) = -17.8$ meV, reflecting the small enhancement in the experiment.

In the simulated curves we can find the same dependence for the threshold, but the threshold is here a steep step, unlike in experiment, because spontaneous emission into the laser mode is not taken into account in our semiclassical model.

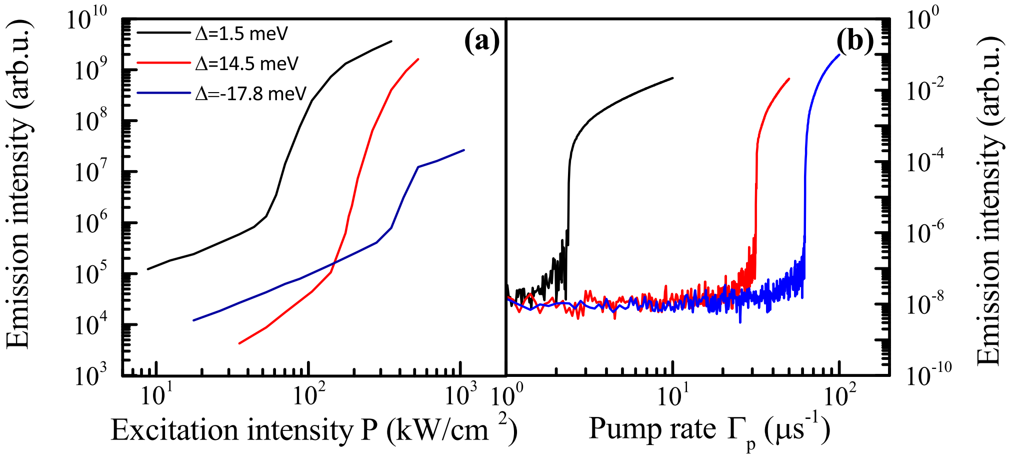

FIG. 1. Experimentally measured (a) and calculated (b) input-output curves for the studied detunings.

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[1] H. Haken, *Laser theory* (Springer, 1970).