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Supporting Information

Tunable amplified spontaneous emission based on liquid magnetically responsive photonic crystals

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Experimental Section

Materials.

All the chemicals used in this work were of analytical grade and were used as received without further purification. Ferric chloride (FeCl_3 , anhydrous), sodium acetate (CH_3COONa , NaAc, anhydrous), poly(vinyl pyrrolidone) (PVP, $M_w=1\ 300\ 000$) were purchased from Sigma-Aldrich. Polyethyleneglycol (PEG, $M_w=2\ 000$) and Rhodamin B (RhB) were purchased from Alfa Aesar. Diethylene glycol (DEG) and ethylene glycol (EG) were purchased from Sinopharm chemical reagent Beijing Co., Ltd. Water used throughout all experiments was purified with the Millipore system.

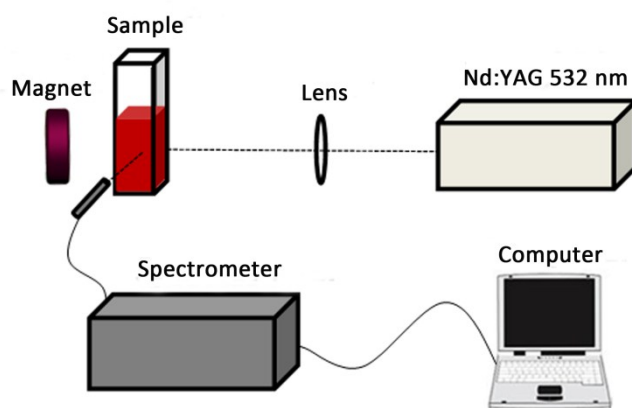
Preparation of Fe_3O_4 @PVP particles.

In a typical procedure, PEG (10 mmol), H_2O (1.1 mL) and FeCl_3 (5 mmol) were first added into EG (15 mL) and mixed for 30 min to form a transparent light yellow solution A. NaAc (12 mmol) was added into DEG (20 ml) by mixing for 30 min to form a colorless and transparent solution B. Then, solution B was added into solution A to form solution C under vigorous stirring. This solution was subsequently heated at $75\ ^\circ\text{C}$ with vigorous stirring for 90 min. Afterwards, the resulting solution was transferred into a 50 mL Teflon-lined stainless-steel autoclave. The autoclave was then sealed and maintained at $200\ ^\circ\text{C}$ for 5 h. After being cooled to room temperature, the final product was collected by a magnet and rinsed with a mixture of ethanol and deionized (DI) water several times before being dispersed in ethanol. PVP (3 g) was dissolved in 60 mL H_2O . The prepared solution was charged into a suspension containing 1 mg Fe_3O_4 particles and stirred for 18 h. The resultant Fe_3O_4 @PVP particles were then centrifuged and washed with a mixture of ethanol and deionized (DI) water and then dispersed in ethanol for the fabrication of liquid magnetically responsive photonic crystals.

Characterization techniques.

Scanning electron microscope (SEM) images were obtained by JEOL S-4800 field emission scanning electron microscope. Transmission electron microscope (TEM) images were taken on JEOL JEM-2100F

transmission electron microscope. X-ray diffraction (XRD) analysis was carried out on a D/Max 2500V/PC X-ray diffractometer ($\lambda=1.54056 \text{ \AA}$) in the 2θ range of $10\text{-}70^\circ$ using Cu-K α radiation. The Fourier transform IR (FTIR) spectrum was obtained using a 60-SXB FTIR spectrometer in the range of $400\text{-}4000 \text{ cm}^{-1}$ with a resolution of 4 cm^{-1} . The magnetic properties of the samples were investigated using a physical property measurement system (PPMS) (Model PPMS-9, Quantum Design, USA) with applied magnetic fields between -8 and 8 kOe at 300 K . The absorption spectrum was collected using a Shimadzu UV-3600 Plus spectrometer. The PL spectrum was obtained using a Hitachi F-4500 fluorescence spectrometer. Optical Bragg diffractions were tested by a fiber spectrometer (AvaSpec-2048, Avantes). These spectra were taken with light impinging perpendicular to the quartz cell containing sample. The diameter of collection spot was approximately 2 mm . The color of the sample was recorded using a common digital camera. Photo-pumped ASE studies were carried out using an excitation beam produced by a pulsed Nd:YAG laser at 532 nm with a pulse duration of 7 ns and pulse rate of 10 Hz . The excitation beam was focused on the sample by a lens with a focal length of 150 mm to a spot with a diameter of 4 mm and the incident beam was along the normal direction of the quartz cell containing sample. The optical emission was tested by a fiber spectrometer (AvaSpec-2048, Avantes). These spectra were taken with light impinging perpendicular to the quartz cell containing sample. The integration time was 100 ms .



Scheme S1. Experimental setup for the measurement of tunable ASE.

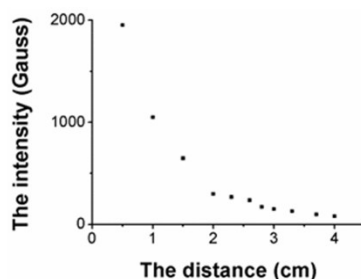


Fig. S1. Change of the magnetic field intensity as a function of the magnet-sample distance.

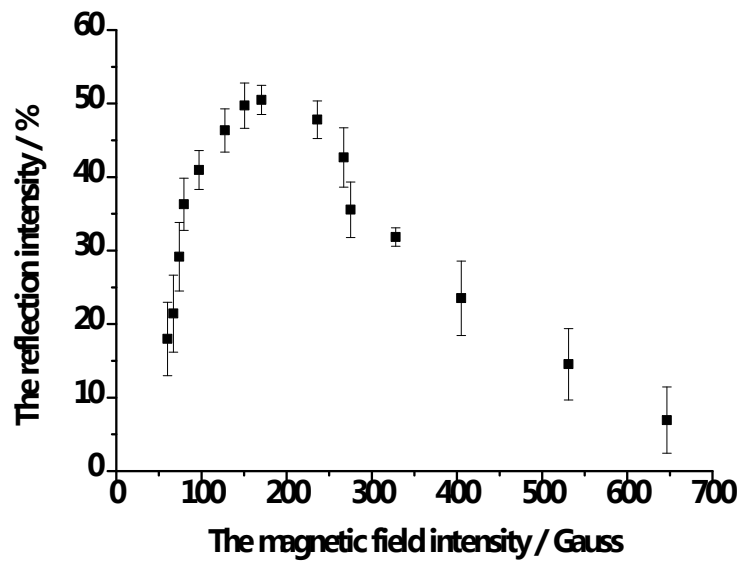


Fig. S2. The relationship between the reflection intensity and the magnetic field intensity.

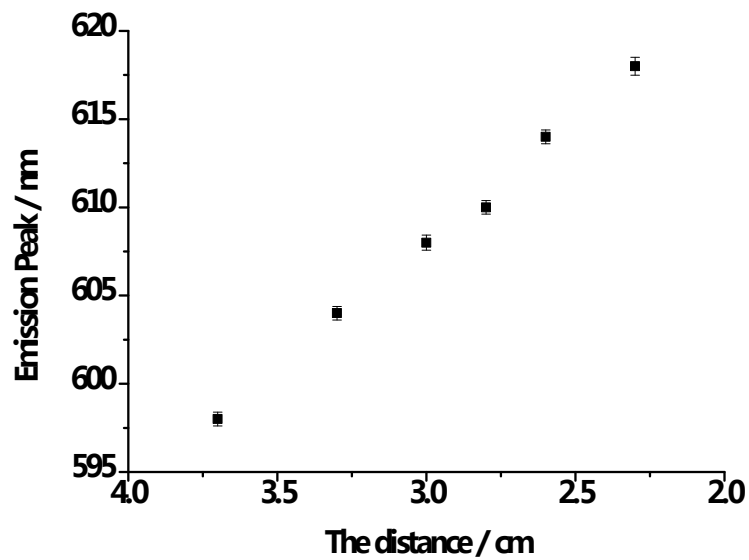


Fig. S3. ASE peaks corresponding to the decreasing distances between the magnet and the sample to achieve tunable ASE.

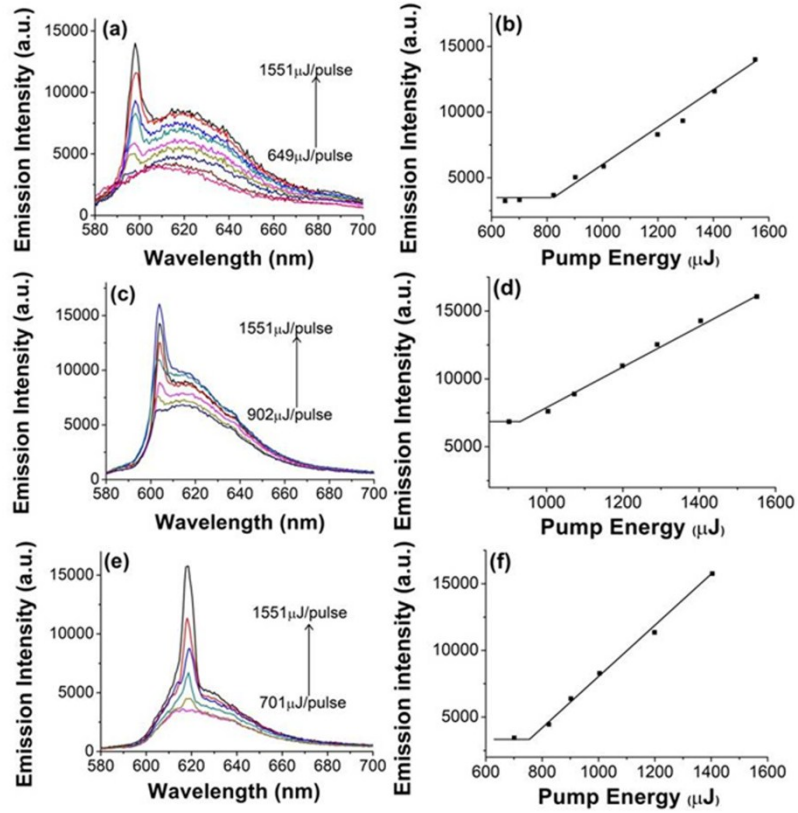


Fig. S4. The ASE spectra and the ASE intensities as functions of excitation intensity. (a), (c), (e) Shows the ASE spectra dependence on excitation intensity, under a pulsed laser excitation (Nd:YAG laser at 532 nm with 7 ns pulse duration). (b), (d), (f) shows the ASE intensities dependence on excitation intensity corresponding to (a), (c), (e). The position of ASE spectra is 598, 604 and 618 nm for (a), (c) and (e), respectively. The threshold excitation intensity is 845, 932, and 755 $\mu\text{J}/\text{pulse}$ for (b), (d), (f), respectively.

Movie S1: Structural color change of the liquid MRPCs when decreasing the magnet-sample distance.