Electronic Supporting Information
Neutral and charged dark excitons in monolayer WS_2

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S1. G-FACTORS OF BRIGHT EXCITONIC COMPLEXES

To get more information on the properties of the bright excitons emissions in the studied WS_2 monolayer, we performed the magneto-photoluminescence experiment in magnetic fields up to 10 T oriented perpendicular to ML's plane. Fig. S1 illustrates the measured PL spectra as a function of magnetic fields in the form of colour-coded map. Upon application of an out-of-plane magnetic field, the excitonic emissions split into two circularly polarized components due to the excitonic Zeeman effect[1]. Their energies evolutions ($E(B)$) in external out-of-plane magnetic fields ($B_\perp$) can be described as:

$$E(B) = E_0 \pm \frac{1}{2} g \mu_B B_\perp, \tag{1}$$

where E_0 is the energy of the transition at zero field, g denotes the g-factor of the considered excitonic complex and μ_B is the Bohr magneton. The results of fitting to the experimental results denoted by red and blue points, are presented in Fig. S2 as solid black curves. We found that the g-factors for the bright exciton (X^B) and singlet (T^S) and triplet (T^T) states of negative trions are of about -3.5, -4.0 and -3.9, respectively. The obtained values are in in very close agreement to previous measurements on WS_2 monolayer[1–5]. Summarizing, the g-factors of the bright excitons, *i.e.* complexes for which recombining an electron and a hole posses the same sign of the spin, are very close to the theoretically predicted value of 4[1].

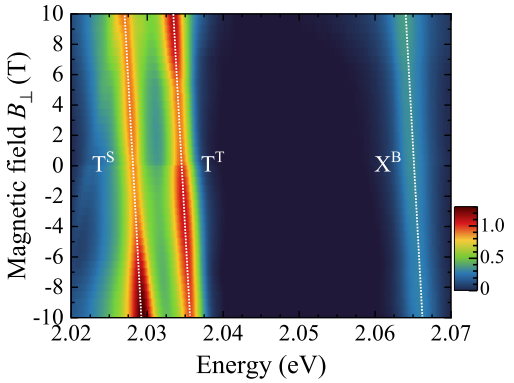

FIG. S1. False-color map of the PL response as a function of $B_\perp$. Note that the positive and negative values of magnetic fields correspond to $\sigma^\pm$ polarizations of detection. The intensity scale is logarithmic. White dashed lines superimposed on the investigated transitions are guides to the eyes.

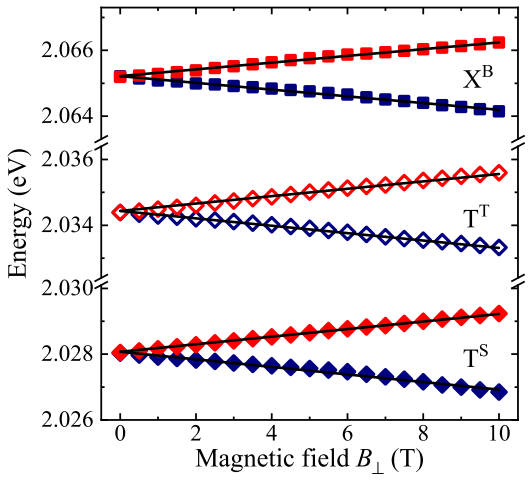

FIG. S2. Transition energies of the $\sigma^{+/-}$ (blue/red points) components of the X^B, T^S and T^T lines as a function of the out-of-plane magnetic field. The solid lines represent fits according to Eq. 1.

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