Electrical generation and control of the valley carriers in a monolayer transition metal dichalcogenide

LETTERS
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Electrical generation and control of the valley carriers in a monolayer transition metal dichalcogenide

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Chao Lv

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Electrical valley generation

Spin-orbit-coupling in 2D TMDC:

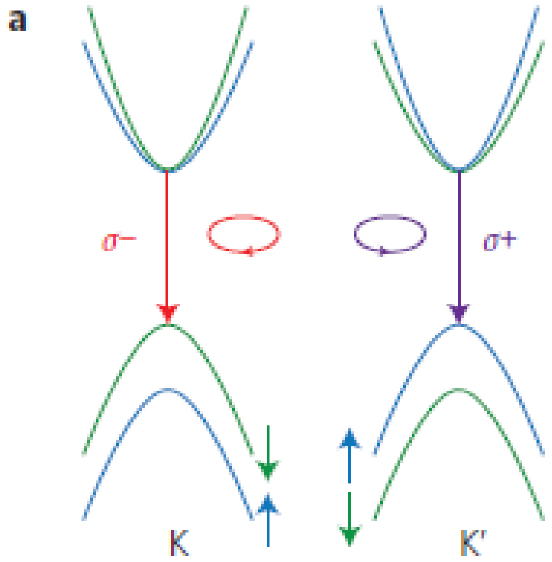

Fig.1 Electronic structure at the K and K' valleys of monolayer TMDC

1. The strong spin–orbit interaction originating from the transition metal ion's d orbitals introduces a large split in the valence bands. The transitions between split valence and conduction band edges are excitonic in nature, termed the A and B excitons.
2. Valley contrasting optical selection rules are therefore expected due to the spin–valley locking in TMDC monolayers.

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Detection in monolayer TMDCs

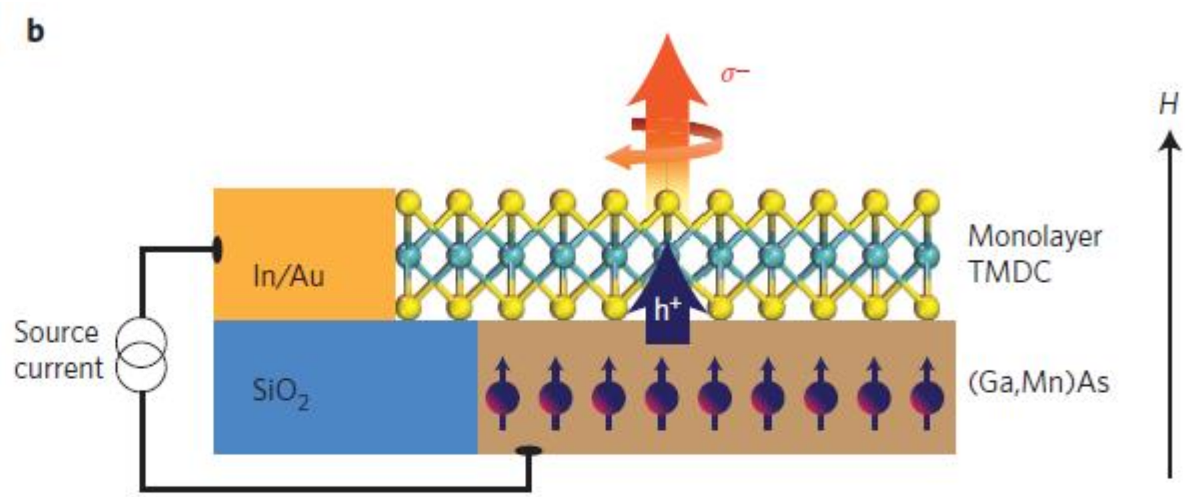

Fig.2 Schematic of the monolayer TMDC/(Ga,Mn)As heterojunction for electrical valley polarization devices.

TMDC: long lifetime of polarized hole and spin-valley locking.

Ferromagnetic semiconductor: conductivity matching and high spin injection efficiency.

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WS_2/(Ga, Mn)As heterostructure

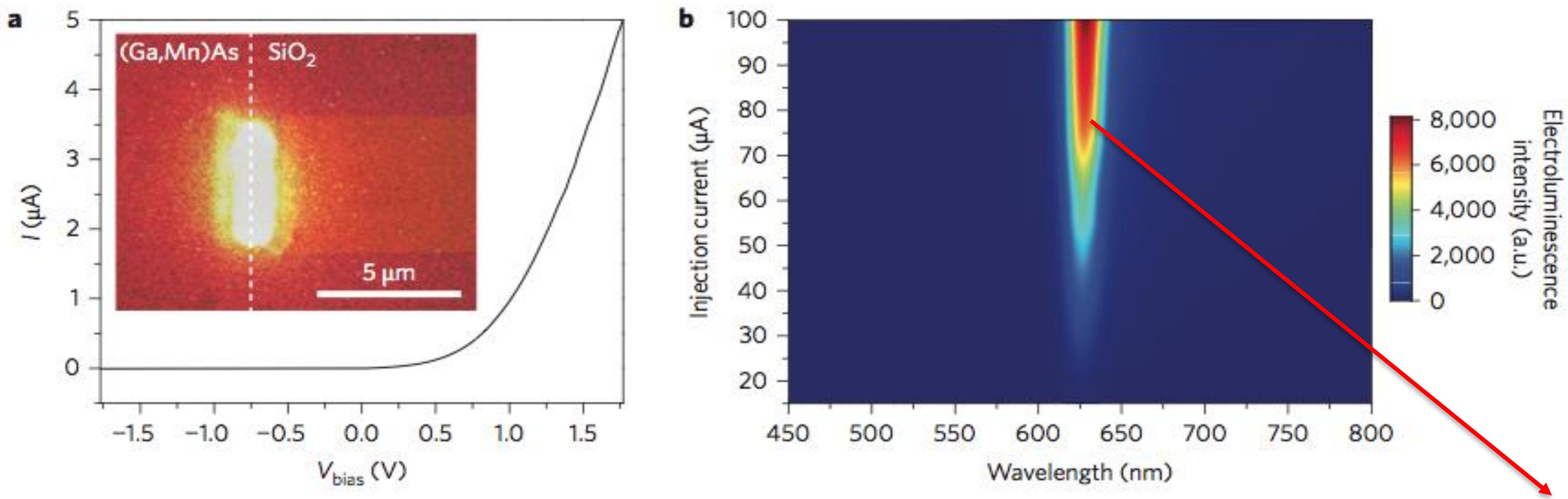

Fig.3 Electroluminescence of the monolayer WS2/(Ga,Mn)As heterojunctions.

1.97 eV
(A exciton)

No defect emission.

Suppression of B exciton emission.

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Electrical Valley excitation in WS_2

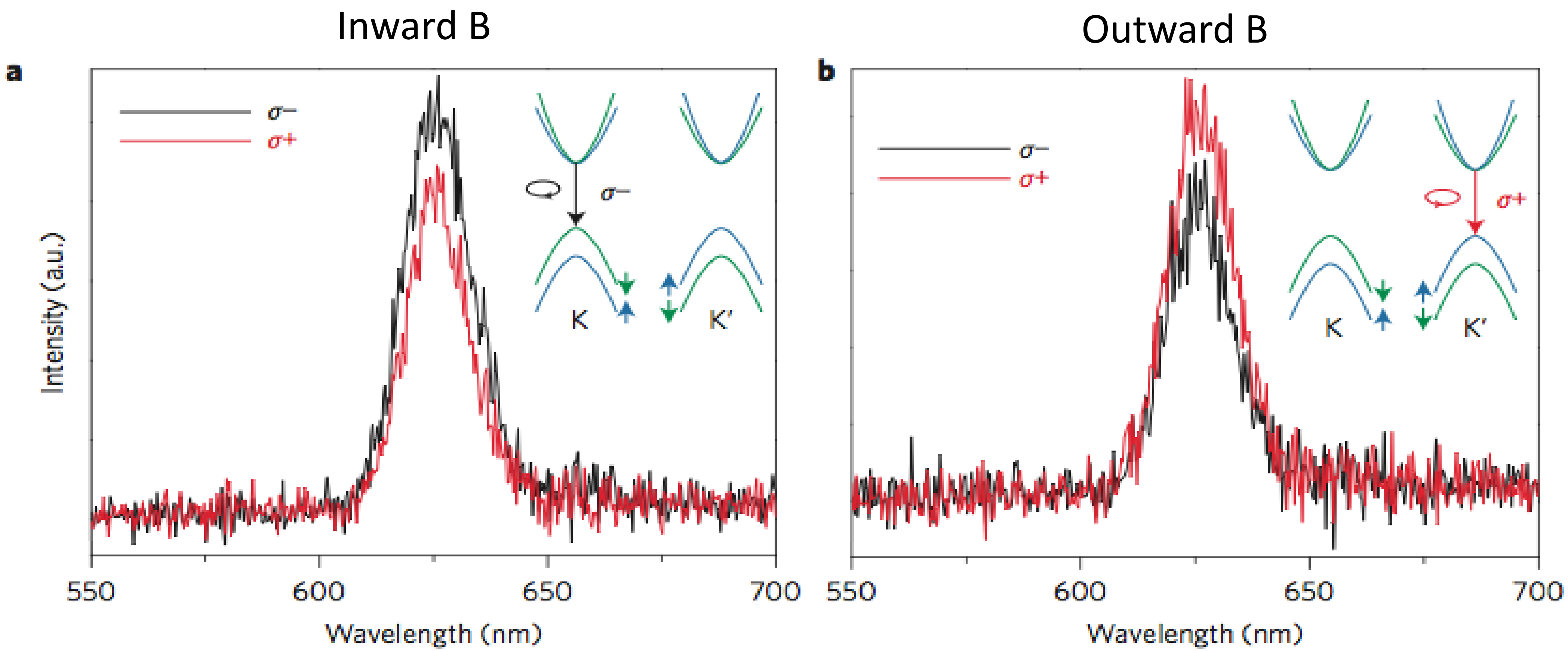

Fig.4 Electrical control of valley polarization in monolayer WS_2.

$$\rho = \frac{I(\sigma_-) - I(\sigma_+)}{I(\sigma_-) + I(\sigma_+)}$$

ρ = 16.2%

ρ = -14.8%

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Magnetic field dependent

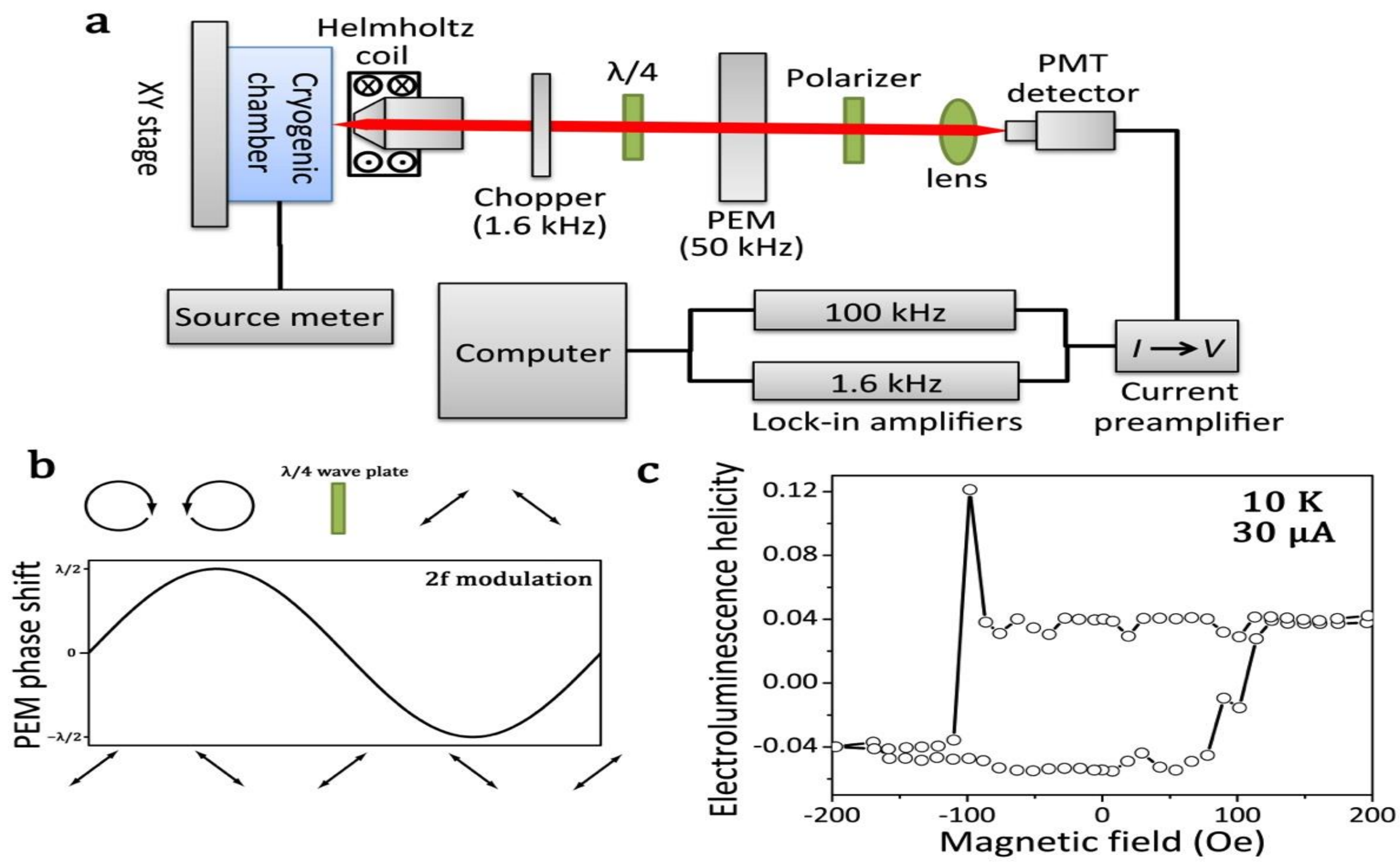

Fig.5 Out-of-plane magnetic field dependence of electroluminescence helicity.

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Valley exciton generation efficiency

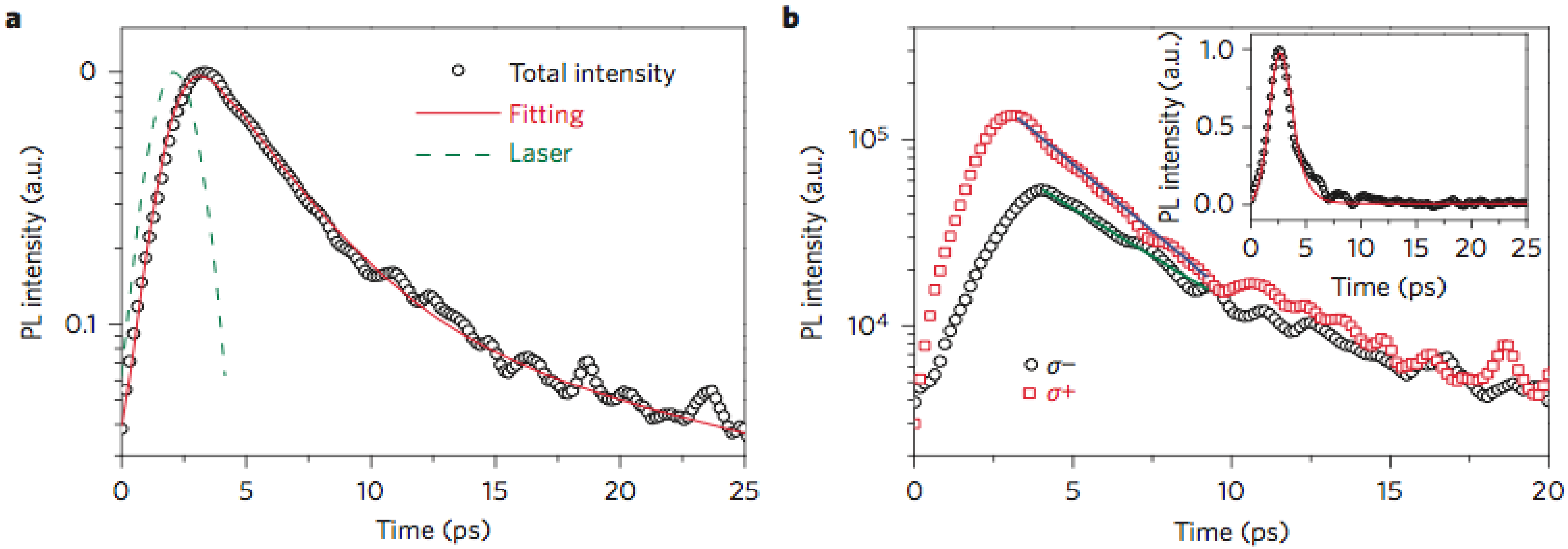

Fig.6 Valley dynamics measurement in monolayer WS_2 on (Ga,Mn)As. a, Time-resolved total photoluminescence using a σ+ polarization femtosecond excitation laser pulse with an energy of 2.21 eV. Convolution fitting with the laser pulse (green dashed line), yields two exciton lifetimes of 2.9 ps and 20.0 ps. b, Time-resolved σ+ and σ− photoluminescence components excited by a σ+ polarized laser..

$$\rho = \frac{N_K - N_{K'}}{N_K + N_{K'}} = \frac{\rho_0}{1 + 2\tau/\tau_K}$$

Non-perfect spin polarization.
Valley scattering.
Joule heating.

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Thanks for your attention