

Control of valley population and quantum Hall effect in a multi-valley system via persistent photoconductivity effect

A. Kazakov,¹ G. Krizman,² V.V. Volobuev,¹ M. Szot,¹ W. Wołkanowicz,¹
C.-W. Cho,^{3,4} B.A. Piot,³ T. Wojciechowski,¹ G. Springholz,⁵
T. Wojtowicz,¹ and T. Dietl¹

¹*International Research Centre MagTop, IFPAN,
Aleja Lotników 32/46, PL-02668 Warsaw, Poland*

²*Laboratoire de Physique de l'École normale supérieure,
ENS, Université PSL, CNRS, Sorbonne Université,
24 rue Lhomond 75005 Paris, France*

³*Laboratoire National des Champs Magnétiques Intenses,
CNRS, LNCMI, Université Grenoble Alpes,
Université Toulouse 3, INSA Toulouse,
EMFL, F-38042 Grenoble, France*

⁴*Department of Physics, Chungnam National University,
Daejeon, 34134, Republic of Korea*

⁵*Institut für Halbleiter- und Festkörperphysik,
Johannes Kepler University, Altenbergerstrasse 69, A-4040 Linz, Austria*

Precise control of the Fermi energy (E_F) is essential to modern semiconductor physics and topological transport. While electrostatic gating is a standard tool for tuning the E_F , persistent photoconductivity (PPC) offers a conceptually distinct, contactless alternative, capable of long-lived and sometimes even bipolar carrier modulation. We demonstrate that persistent photoconductivity offers an efficient method for tuning carrier density and conductivity type with simultaneous valley occupation in Pb-SnSe/PbEuSe quantum wells [1,2]. Illumination with a green LED drives large E_F shifts that transform the system from a threefold-degenerate \bar{M} -valley 2D hole gas into a single-degenerate $\bar{\Gamma}$ -valley 2D electron gas. The photoinduced state is remarkably stable, persisting for days at cryogenic temperatures, and enables stepwise optical gating without device fabrication. Hall-effect sign reversal and changes in quantum Hall plateau degeneracies confirm these changes, while Landau-level $k \cdot p$ calculations [2] quantitatively reproduce the observations. Spectral studies allowed us to identify wavelengths that can reverse the shifts in E_F , thereby making PPC a fully reversible tool for Fermi-level control in future IV-VI topological heterostructures [3].

References:

- [1] G. Krizman, *et al.*, PRL **132**, 166601 (2024)
- [2] A. Kazakov, *et al.*, PRB **111**, 245419 (2025)
- [3] S. Majewski, *et al.*, *arXiv:2601.16137* (2026)

This research was partially supported by the Foundation for Polish Science project "MagTop" no. FENG.02.01-IP.05-0028/23 co-financed by the European Union from the funds of Priority 2 of the European Funds for a Smart Economy Program 2021-2027 (FENG) and by NCN IMPRESS-U Project No. 2023/05/Y/ST3/00191.