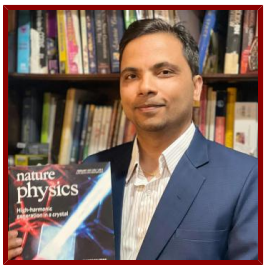
Stanford




# Shambhu Ghimire

Lead Scientist, Energy Sciences

Curriculum Vitae available Online

## Bio

### BIO

Shambhu Ghimire is a Principal Investigator and a Group Leader at Stanford PULSE Institute. He teaches Ultrafast Quantum Dynamics in Applied physics and Physics Department at Stanford. Ghimire's research interests are in ultrafast AMO and Condensed Matter Physics, which includes the use of world's first X-ray free-electron laser, Linac Coherent Light Source (LCLS), as well as the table-top lasers and high-harmonics systems that his team has pioneered at SLAC. They observed high-harmonics from bulk crystals subjected to intense mid-infrared laser pulses for the first time in 2010. Since then, they have been investigating the underlying generation mechanism for their potential spectroscopic applications. The latest discoveries include the use of high-harmonics in ultrafast spectroscopy of two-dimensional crystals and topological insulators, which includes the capability to probe crystal symmetries and topological phase transitions in all-optical settings. Ghimire has been recognized as an Optica Fellow in 2024 for his pioneering contributions to strong-field and attosecond physics in condensed matter systems. Ghimire had received prestigious young investigator award from U. S. Department of Energy in 2014. Before joining Stanford, Ghimire did a post-doc work at University of Michigan, following a Ph.D degree in atomic, molecular and optical physics from Kansas State University in 2007.

### CURRENT ROLE AT STANFORD

Principal Investigator in a DOE-funded research area: High-order Harmonic Generation (HHG)

### INSTITUTE AFFILIATIONS

- Principal Investigator, Stanford PULSE Institute

### HONORS AND AWARDS

- Early Career Award, U.S. Department of Energy (2014-2019)

### EDUCATION AND CERTIFICATIONS

- Ph.D, Kansas State University , Physics (2007)
- Post-doctoral, University of Michigan , Ultrafast Science (2009)

### LINKS

- Research Group Page: https://ultrafast.stanford.edu/Research/strong-field-physics
- Post-doc positions available: https://careers.slac.stanford.edu/sites/careers.slac.stanford.edu/files/Job_Listing_postdoc_HHG2020.pdf
- Full publication list: https://scholar.google.com/citations?user=u7__4foAAAAJ&hl=en

# Professional

## PROFESSIONAL INTERESTS

My research interests are in ultrafast condensed matter, atomic, molecular and optical physics. Currently, we are studying extremely non-linear optical response of quantum materials such as two-dimensional crystals, topological insulators and Weyl semi-metals. Here, the strength of laser field is often comparable to the binding strengths of the material, therefore the typical approximations of nonlinear optics breakdown spectacularly. In 2010, our group discovered that materials subjected to such strong fields produce high-order harmonics of driving laser. In the first experiment, we observed high-harmonics up to 25th orders from zinc oxide crystals subjected to intense mid-infrared laser. Since then there has been a lot of exciting work in the field, which includes understanding the microscopic mechanism of high-harmonic generation and using it to probe materials properties. Some of the properties this scheme can probe are valence charge distributions, electronic band structure, Berry curvature, and quantum mechanical phase transitions including topological phase transitions.

# Publications

## PUBLICATIONS

- **Ultrafast high-harmonic spectroscopy of solids** *Nature Physics*
  Heide, C., Kobayashi, Y., Haque, S., Ghimire, S.
  2024
- **Giant room-temperature nonlinearities in a monolayer Janus topological semiconductor.** *Nature communications*
  Shi, J., Xu, H., Heide, C., HuangFu, C., Xia, C., de Quesada, F., Shen, H., Zhang, T., Yu, L., Johnson, A., Liu, F., Shi, E., Jiao, et al
  2023; 14 (1): 4953
- **High-harmonic generation from artificially stacked 2D crystals** *NANOPHOTONICS*
  Heide, C., Kobayashi, Y., Johnson, A. C., Heinz, T. F., Reis, D. A., Liu, F., Ghimire, S.
  2023
- **Floquet engineering of strongly driven excitons in monolayer tungsten disulfide** *NATURE PHYSICS*
  Kobayashi, Y., Heide, C., Johnson, A. C., Tiwari, V., Liu, F., Reis, D. A., Heinz, T. F., Ghimire, S.
  2023
- **Intense infrared lasers for strong-field science** *ADVANCES IN OPTICS AND PHOTONICS*
  Chang, Z., Fang, L., Fedorov, V., Geiger, C., Ghimire, S., Heide, C., Ishii, N., Itatani, J., Joshi, C., Kobayashi, Y., Kumar, P., Marra, A., Mirov, et al
  2022; 14 (4): 652-782
- **Proposal for High-Energy Cutoff Extension of Optical Harmonics of Solid Materials Using the Example of a One-Dimensional ZnO Crystal.** *Physical review letters*
  Lang, Y., Peng, Z., Liu, J., Zhao, Z., Ghimire, S.
  2022; 129 (16): 167402
- **Probing topological phase transitions using high-harmonic generation** *NATURE PHOTONICS*
  Heide, C., Kobayashi, Y., Baykusheva, D. R., Jain, D., Sobota, J. A., Hashimoto, M., Kirchmann, P. S., Oh, S., Heinz, T. F., Reis, D. A., Ghimire, S.
  2022
- **Probing electron-hole coherence in strongly driven 2D materials using high-harmonic generation** *OPTICA*
  Heide, C., Kobayashi, Y., Johnson, A. C., Liu, F., Heinz, T. F., Reis, D. A., Ghimire, S.
  2022; 9 (5): 512-516
- **Probing attosecond phenomena in solids** *NATURE PHOTONICS*
  Ghimire, S.
  2021
- **All-Optical Probe of Three-Dimensional Topological Insulators Based on High-Harmonic Generation by Circularly Polarized Laser Fields.** *Nano letters*

Baykusheva, D., Chacon, A., Lu, J., Bailey, T. P., Sobota, J. A., Soifer, H., Kirchmann, P. S., Rotundu, C., Uher, C., Heinz, T. F., Reis, D. A., Ghimire, S.
2021

- **Strong-field physics in three-dimensional topological insulators** *PHYSICAL REVIEW A*
  Baykusheva, D., Chacon, A., Kim, D., Kim, D., Reis, D. A., Ghimire, S.
  2021; 103 (2)
- **The effect of photo-carrier doping on the generation of high harmonics from MoS2**
  Heide, C., Kobayashi, Y., Liu, F., Ghimire, S., Heinz, T. F., Reis, D. A., IEEE
  IEEE.2021
- **Attosecond synchronization of extreme ultraviolet high harmonics from crystals** *JOURNAL OF PHYSICS B-ATOMIC MOLECULAR AND OPTICAL PHYSICS*
  Vampa, G., Lu, J., You, Y., Baykusheva, D. R., Wu, M., Liu, H., Schafer, K. J., Gaarde, M. B., Reis, D. A., Ghimire, S.
  2020; 53 (14)
- **Attosecond science based on high harmonic generation from gases and solids.** *Nature communications*
  Li, J., Lu, J., Chew, A., Han, S., Li, J., Wu, Y., Wang, H., Ghimire, S., Chang, Z.
  2020; 11 (1): 2748
- **Strong-field physics in three-dimensional topological insulators** *Strong-field physics in three-dimensional topological insulators*
  Baykusheva, D., et al
  2020
- **High-harmonic generation from an epsilon-near-zero material** *NATURE PHYSICS*
  Yang, Y., Lu, J., Manjavacas, A., Luk, T. S., Liu, H., Kelley, K., Maria, J., Runnerstrom, E. L., Sinclair, M. B., Ghimire, S., Brener, I.
  2019; 15 (10): 1022-+
- **Interferometry of dipole phase in high harmonics from solids** *NATURE PHOTONICS*
  Lu, J., Cunningham, E. F., You, Y., Reis, D. A., Ghimire, S.
  2019; 13 (2): 96-+
- **Crystal orientation-dependent polarization state of high-order harmonics** *OPTICS LETTERS*
  You, Y., Lu, J., Cunningham, E. F., Roedel, C., Ghimire, S.
  2019; 44 (3): 530–33
- **High-harmonic generation from solids** *NATURE PHYSICS*
  Ghimire, S., Reis, D. A.
  2019; 15 (1): 10–16
- **High-Harmonic Generation from Topological Insulators**
  Baykusheva, D., Lu, J., Sobota, J. A., Soifer, H., Rotundu, C. R., Kirchmann, P. S., Reis, D. A., Ghimire, S., IEEE
  IEEE.2019
- **Probing periodic potential of crystals via strong-field re-scattering** *JOURNAL OF PHYSICS B-ATOMIC MOLECULAR AND OPTICAL PHYSICS*
  You, Y., Cunningham, E., Reis, D. A., Ghimire, S.
  2018; 51 (11)
- **Locking the waveform with a quartz crystal** *NATURE PHOTONICS*
  Ghimire, S.
  2018; 12 (5): 256–57
- **Polarimetry of High Harmonics in Bulk Crystals**
  You, Y., Cunningham, E., Rodel, C., Reis, D. A., Ghimire, S., IEEE
  IEEE.2018
- **Emission Phase of Extreme Ultraviolet High Harmonics from Bulk Crystals**
  Lu, J., You, Y., Reis, D. A., Ghimire, S., IEEE
  IEEE.2018

- **Orientation dependence of temporal and spectral properties of high-order harmonics in solids** *PHYSICAL REVIEW A*
  Wu, M., You, Y., Ghimire, S., Reis, D. A., Browne, D. A., Schafer, K. J., Gaarde, M. B.
  2017; 96 (6)
- **High-harmonic generation in amorphous solids** *NATURE COMMUNICATIONS*
  You, Y., Yin, Y., Wu, Y., Chew, A., Ren, X., Zhuang, F., Gholam-Mirzaei, S., Chini, M., Chang, Z., Ghimire, S.
  2017; 8: 724
- **Laser waveform control of extreme ultraviolet high harmonics from solids** *OPTICS LETTERS*
  You, Y. S., Wu, M., Yin, Y., Chew, A., Ren, X., Gholam-Mirzaei, S., Browne, D. A., Chini, M., Chang, Z., Schafer, K. J., Gaarde, M. B., Ghimire, S.
  2017; 42 (9): 1816-1819
- **Anisotropic high-harmonic generation in bulk crystals** *NATURE PHYSICS*
  You, Y. S., Reis, D. A., Ghimire, S.
  2017; 13 (4): 345-349
- **High-harmonic generation from an atomically thin semiconductor** *NATURE PHYSICS*
  Liu, H., Li, Y., You, Y. S., Ghimire, S., Heinz, T. F., Reis, D. A.
  2017; 13 (3): 262-?
- **Phase-coherence of high-order harmonics from bulk crystals using homodyne detection**
  Cunningham, E., You, Y., Reis, D. A., Ghimire, S., IEEE
  IEEE.2017
- **High-order harmonics from bulk and 2D crystals**
  You, Y., Ndabashimiye, G., Liu, H., Li, Y., Heinz, T. F., Reis, D. A., Ghimire, S., IEEE
  IEEE.2017
- **Waveform control of high-harmonic generation in solids**
  You, Y., Wu, M., Yin, Y., Chew, A., Ren, X., Gholam-Mirzaei, S., Browne, D. A., Chini, M., Chang, Z., Schafer, K. J., Gaarde, M. B., Ghimire, S., IEEE
  IEEE.2017
- **Nonsequential two-photon absorption from the K shell in solid zirconium** *PHYSICAL REVIEW A*
  Ghimire, S., Fuchs, M., Hastings, J., Herrmann, S. C., Inubushi, Y., Pines, J., Shwartz, S., Yabashi, M., Reis, D. A.
  2016; 94 (4)
- **Solid-state harmonics beyond the atomic limit** *NATURE*
  Ndabashimiye, G., Ghimire, S., Wu, M., Browne, D. A., Schafer, K. J., Gaarde, M. B., Reis, D. A.
  2016; 534 (7608): 520-?
- **High harmonics from solids probe Angstrom scale structure**
  You, Y., Reis, D. A., Ghimire, S., IEEE
  IEEE.2016
- **Anomalous nonlinear X-ray Compton scattering** *NATURE PHYSICS*
  Fuchs, M., Trigo, M., Chen, J., Ghimire, S., Shwartz, S., Kozina, M., Jiang, M., Henighan, T., Bray, C., Ndabashimiye, G., Bucksbaum, P. H., Feng, Y., Herrmann, et al
  2015; 11 (11): 964-970
- **High-harmonic generation from Bloch electrons in solids** *PHYSICAL REVIEW A*
  Wu, M., Ghimire, S., Reis, D. A., Schafer, K. J., Gaarde, M. B.
  2015; 91 (4)
- **Strong-field and attosecond physics in solids** *JOURNAL OF PHYSICS B-ATOMIC MOLECULAR AND OPTICAL PHYSICS*
  Ghimire, S., Ndabashimiye, G., DiChiara, A. D., Sistrunk, E., Stockman, M. I., Agostini, P., DiMauro, L. F., Reis, D. A.
  2014; 47 (20)
- **Measurement of coherence Lengths of Below Threshold Harmonics in Solid Argon**
  Ndabashimiye, G., Ghimire, S., Nicholson, D., Reis, D. A., IEEE
  IEEE.2013

- **Generation and propagation of high-order harmonics in crystals** *PHYSICAL REVIEW A*
  Ghimire, S., DiChiara, A. D., Sistrunk, E., Ndabashimiye, G., Szafruga, U. B., Mohammad, A., Agostini, P., DiMauro, L. F., Reis, D. A.
  2012; 85 (4)

- **Scaling of High-Order Harmonic Generation in the Long Wavelength Limit of a Strong Laser Field** *IEEE JOURNAL OF SELECTED TOPICS IN QUANTUM ELECTRONICS*
  DiChiara, A. D., Ghimire, S., Blaga, C. I., Sistrunk, E., Power, E. P., March, A. M., Miller, T. A., Reis, D. A., Agostini, P., DiMauro, L. F.
  2012; 18 (1): 419-433

- **High-order harmonic generation in solid argon** *Conference on Lasers and Electro-Optics (CLEO)*
  Ghimire, S., Ndabashimiye, G., Reis, D. A.
  IEEE.2012

- **Redshift in the Optical Absorption of ZnO Single Crystals in the Presence of an Intense Midinfrared Laser Field** *PHYSICAL REVIEW LETTERS*
  Ghimire, S., DiChiara, A. D., Sistrunk, E., Szafruga, U. B., Agostini, P., DiMauro, L. F., Reis, D. A.
  2011; 107 (16)

- **Single-cycle terahertz pulses with > 0.2 V/angstrom field amplitudes via coherent transition radiation** *APPLIED PHYSICS LETTERS*
  Daranciang, D., Goodfellow, J., Fuchs, M., Wen, H., Ghimire, S., Reis, D. A., Loos, H., Fisher, A. S., Lindenberg, A. M.
  2011; 99 (14)

- **Nonlinear Atomic Response to Intense Ultrashort X Rays** *PHYSICAL REVIEW LETTERS*
  Doumy, G., Roedig, C., Son, S., Blaga, C. I., DiChiara, A. D., Santra, R., Berrah, N., Bostedt, C., Bozek, J. D., Bucksbaum, P. H., Cryan, J. P., Fang, L., Ghimire, et al
  2011; 106 (8)

- **Observation of high-order harmonic generation in a bulk crystal** *NATURE PHYSICS*
  Ghimire, S., DiChiara, A. D., Sistrunk, E., Agostini, P., DiMauro, L. F., Reis, D. A.
  2011; 7 (2): 138-141

- **Strong-field Induced Optical Absorption in ZnO Crystal** *Conference on Lasers and Electro-Optics (CLEO)*
  Ghimire, S., DiChiara, A. D., Sistrunk, E., DiMauro, L. F., Agostini, P., Reis, D. A.
  IEEE.2011

- **Femtosecond electronic response of atoms to ultra-intense X-rays** *NATURE*
  Young, L., Kanter, E. P., Kraessig, B., Li, Y., March, A. M., Pratt, S. T., Santra, R., Southworth, S. H., Rohringer, N., DiMauro, L. F., Doumy, G., Roedig, C. A., Berrah, et al
  2010; 466 (7302): 56-U66

- **High-Harmonic Generation in Strongly Driven Bulk Periodic Solid** *Conference on Lasers and Electro-Optics (CLEO)/Quantum Electronics and Laser Science Conference (QELS)*
  Ghimire, S., DiChiara, A., Sistrunk, E., DiMauro, L. F., Agostini, P., Reis, D. A.
  IEEE.2010

- **Measurement of attosecond XUV pulses generated with polarization gating by two-dimensional photoelectron spectroscopy**
  Ghimire, S., Feng, X., Chang, Z.
  edited by Chang, Z., Kyrala, G. A., Kieffer, J. C.
  SPIE-INT SOC OPTICAL ENGINEERING.2007