APN-000

LineScan in Academic Research

Overview

This Application Note highlights peer-reviewed publications that have employed LineScan cameras by Synertronic Designs in advanced spectroscopic and photophysical investigations. Applications span femtosecond-resolved transient absorption, terahertz spectroscopy, and polarization-resolved measurements across a range of molecular and material systems. The listed studies demonstrate the integration of LineScan imaging in high-precision experimental setups within leading research institutions.

01. Simplifying the Analysis of Ultrafast Dynamics by Polarization Control

Author: Xu, Yi; Advisor: Hauer, Jürgen (Prof. Dr.); Referee: Hauer, Jürgen (Prof. Dr.); Kartouzian, Aras (Dr.)

Year: 2024

Faculty/Institution: Professur für Dynamische Spektroskopien (Prof. Hauer), TUM School of Natural Sciences, Technical University of Munich

Abstract:

Transient absorption spectroscopy (TAS) is a powerful technique to study the dynamics of photo-excited states in various systems. This thesis shows how transient spectra can be disentangled by applying a polarization-based strategy. This approach greatly reduces spectral congestion in complex systems and provides information on the directions of transition dipole moments (TDMs).

Source:

https://mediatum.ub.tum.de/1744438

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02. Atomically Precise Distorted Nanographenes: The Effect of Different Edge Functionalization on the Photophysical Properties down to the Femtosecond Scale

Authors: Marco Reale, Alice Sciortino, Marco Cannas, Ermelinda Maçoas, Arthur H. G. David, Carlos M. Cruz, Araceli G. Campaña and Fabrizio Messina

Year: 2023

Faculty / Institution:

- Advanced Technologies Network Center, Università degli Studi di Palermo, Viale delle Scienze Ed. 18/A, 90128 Palermo, Italy
- Centro de Química Estrutural e Institute of Molecular Sciences, Instituto Superior Técnico, Universidade de Lisboa (Portugal), Av. Rovisco Pais 1, 1049-001 Lisboa, Portugal
- Department of Organic Chemistry, Unidad de Excelencia de Química (UEQ), Faculty of Sciences, University of Granada, Avda. Fuente Nueva s/n, 18071 Granada, Spain

Abstract:

Nanographenes (NGs) have been attracting widespread interest since they combine peculiar properties of graphene with molecular features, such as bright visible photoluminescence. However, our understanding of the fundamental properties of NGs is still hampered by the high degree of heterogeneity usually characterizing most of these materials. In this context, NGs obtained by atomically precise synthesis routes represent optimal benchmarks to unambiguously relate their properties to well-defined structures. Here we investigate in deep detail the optical response of three curved hexa-peri-hexabenzocoronene (HBC) derivatives obtained by atomically precise synthesis routes. They are constituted by the same graphenic core, characterized by the presence of a heptagon ring determining a saddle distortion of their sp2 network, and differ from each other for slightly different edge functionalization. The quite similar structure allows for performing a direct comparison of their spectroscopic features, from steady-state down to the femtosecond scale, and precisely disentangling the role played by the different edge chemistry.

Keywords: atomically precise nanographenes; fluorescent nanomaterials; distorted hexa-peri-hexabenzocoronene derivatives; optical properties

Source:

https://www.mdpi.com/1996-1944/16/2/835

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03. Ultrafast photochromism in metal-organic complexes

Author: Von Stein, Xavier

Year: 2016

Faculty/Institution: Faculty of Science. Dept. of Physics, Stellenbosch University

Abstract:

Dithizone (H2Dz), an analytical reagent typically used in colourimetric analysis, reacts with various transition metals to form metal dithizonate complexes. These complexes display strong absorption in the visible region of the spectrum and exhibit photochromism: a photo-induced reversible transformation of the reactant to a product form with a distinctly different absorption spectrum. The photo-isomerisation of a C=N bond in the dithizone's backbone is responsible for this behaviour. This mechanism was confirmed in 2011 by the first ultra-fast study on dithizonatophenylmercury(II) (DPM), a singleliganded complex. To compliment this study, transient absorption spectroscopy was used to capture temporally and spectrally resolved spectra of the photo-induced reaction in the dithizone ligand and select two-liganded dithizontates following excitation at their absorption maxima. The ligand, as well as the two-liganded Hg(HDz)2, Pb(HDz)2 and Zn(HDz)2 complexes showed two reaction paths following photo-excitation. The first path is associated with an evolution along the rotational isomerisation coordinate which leads to product formation and ground state recovery with a time constant of 1 ps.

This is in accordance to what was found for DPM. The second reaction path leads to a re-population of the ground state with a time constant of 10 ps. A physical process could not definitively be assigned to the second pathway, although it is speculated that it may be due to an unstable intermediate along the C=N inversion coordinate. As the 1 and 10 ps paths were found to be intrinsic to the ligand, it was concluded that the second ligand does not participate in the dynamics, at least not on times below 500 ps. The Ni(HDz)2 complex was not analysed in detail due to complexities that arise given the possibility of ligand-ligand interactions and possible metal to ligand or ligand to metal charge transfer processes.

Keywords: Photoisomerisation, Photochromism, Photochemistry, Metal dithizonates, Spectroscopy, UCTD

Source:

https://scholar.sun.ac.za/items/6da17aaa-bc25-4393-9150-5e430a741eec

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04. Molecular Aggregates Associated THz Coherent Vibrations Contribute to Enhancements of Emission Efficiencies

Authors: Yu-Chen Wei, Bo-Han Chen, Ren-Siang Ye, Hsing-Wei Huang, Jia-Xuan Su, Kai Chen, Lian-Yan Hsu, Yun Chi, Chih-Hsuan Lu, Shang-Da Yang, Pi-Tai Chou

Year: 2022

Faculty/Institution:

- Department of Chemistry, National Taiwan University
- Institute of Photonics Technologies, National Tsing Hua University
- Robinson Research Institute, Faculty of Engineering, Victoria University of Wellington
- The Dodd-Walls Centre for Photonic and Quantum Technologies
- MacDiarmid Institute for Advanced Materials and Nanotechnology
- Institute of Atomic and Molecular Sciences, Academia Sinica
- Department of Materials Science and Engineering, Department of Chemistry, and Center of Super-Diamond and Advanced Films (COSDAF), City University of Hong Kong

Abstract:

The control of excited-state vibrational and electronic energy flows in molecular solids has a considerable impact on the performance of optoelectronic devices. In this study, we applied a novel ultrafast pump-probe system with 3.2 fs resolution to demonstrate that the aggregated Pt(II) complex 4H, an efficient near infrared emitter, exhibits prominent single-mode vibrational coherence (VC) with a frequency of 32 cm−1 (~ 0.96 THz) in the excited state. This single-mode VC isassociated with the collective out-of-plane motions induced by intermolecular metal-metal-to-ligand charge transfer transitions, which occur through ultrafast intersystem crossings with lifetimes of 150 fs. Similar single-mode VC characteristics were observed in analogues of 4H and other Pt(II) complexes with intense NIR emission. The conservation of single-mode VC enables excited-state deactivation to proceed along low-frequency coordinates, which contributes to the suppression of nonradiative decay rates and causes highly 36 intense near-infrared emission in aggregated Pt(II) complexes. These novel results highlight the importance of VC in understanding nonradiative processes, elucidating the foundations of VC in molecular solid, which serve as a benchmark for evolving the device performance.

Source:

https://web.archive.org/web/20221006183924id_/https://assets.researchsquare.com/files/rs-2118385/v1_covered.pdf?c=1665079493

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05. Two-dimensional ultrafast transient absorption spectrograph covering deep-ultraviolet to visible spectral region optimized for biomolecules

Authors: Maryam Nazari Haghighi Pashaki, Nina Mosimann-Schönbächler, Aaron Riede, Michela Gazzetto, Ariana Rondi and Andrea Cannizzo

Year: 2021

Faculty/Institution: Institute of Applied Physics, University of Bern

Abstract:

We report on the implementation of a multi-kHz single-shot referenced non-coherent two-dimensional UV spectrograph based on conventional pump-probe geometry. It has the capability to cover a broad spectral region in excitation from 270-to-380 nm and in the detection from 270-to-390 nm and 320-to-720 nm. Other setups features are: an unprecedented time resolution of 33 fs (standard deviation); signals are photometrically corrected; a single-shot noise of <1 mOD. It has the capability to operate with sample volumes as small as few μ l which is an accomplishment in studying biological or biomimetic systems. To show its performances and potentials, we report two preliminary studies on the photophysics of phenanthrenes hosted in a multichromophoric antenna system and of aromatic amino acids in a blue-copper azurin.

Source:

https://iopscience.iop.org/article/10.1088/2515-7647/ac0805/meta

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06. Determining Excited-State Absorption Properties of a Quinoid Flavin by Polarization-Resolved Transient Spectroscopy

Authors: Yi Xu, Martin T. Peschel, Miriam Jänchen, Richard Foja, Golo Storch, Erling Thyrhaug, Regina de Vivie-Riedle, and Jürgen Hauer

Year: 2024

Faculty/Institution:

- Department of Chemistry and Catalysis Research Center, TUM School of Natural Sciences, Technical University of Munich
- Department of Chemistry, Ludwig-Maximilians-Universität München

Abstract:

As important naturally occurring chromophores, photophysical/chemical properties of quinoid flavins have been extensively studied both experimentally and theoretically. However, little is known about the transition dipole moment (TDM) orientation of excited-state absorption transitions of these important compounds. This aspect is of high interest in the fields of photocatalysis and quantum control studies. In this work, we employ polarization-associated spectra (PAS) to study the excited-state absorption transitions and the underlying TDM directions of a standard quinoid flavin compound. As compared to transient absorption anisotropy (TAA), an analysis based on PAS not only avoids diverging signals but also retrieves the relative angle for ESA transitions with respect to known TDM directions. Quantum chemical calculations of excited-state properties lead to good agreement with TA signals measured in magic angle configuration. Only when comparing experiment and theory for TAA spectra and PAS, do we find deviations when and only when the S0 ⟶ S1 of flavin is used as a reference. We attribute this to the vibronic coupling of this transition to a dark state. This effect is only observed in the employed polarization-controlled spectroscopy and would have gone unnoticed in conventional TA.

Source:

https://pubs.acs.org/doi/full/10.1021/acs.jpca.4c01260

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07. Reduction of recombination rates due to volume increasing, annealing, and tetraethoxysilicate treatment in hematite thin films

Authors: S. Congolo, M. J. Madito, A. T. Paradzah, A. J. Harrison, H. M. A. M. Elnour, T. P. J. Krüger & M. Diale

Year: 2020

Faculty/Institution:

- Department of Physics, University of Pretoria
- iThemba LABS, National Research Foundation

Abstract:

We report on the properties of hematite thin films prepared by spray pyrolysis on fluorine-doped tin oxide (FTO)-coated glass substrates and investigated the effect of the spray volume, tetraethoxysilicate treatment of the hematite, and post-annealing at 500 °C for 2 h with 10 °C/min ramping. Raman spectroscopy confirmed the characteristic Raman spectrum of all the films, while high-resolution confocal Raman microscopy showed a uniform intensity, suggesting a homogeneous coating of the hematite films on the FTO substrates. Ultrafast transient absorption spectroscopy indicates that all three experimental parameters—a larger spray volume, tetraethoxysilicate treatment, and annealing—slowed down electron–hole recombination. Global analysis of the difference absorption data resolved the spectra and associated decay lifetimes of three distinct processes, operating on the ultrafast, tens of picoseconds, and hundreds of picoseconds timescales.

Source:

https://link.springer.com/article/10.1007/s13204-020-01264-7

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08. Optical-pump–terahertz-probe spectroscopy in high magnetic fields with kHz single-shot detection

Authors: Blake S. Dastrup, Peter R. Miedaner, Zhuquan Zhang, Keith A. Nelson

Year: 2024

Faculty/Institution: Department of Chemistry, Massachusetts Institute of Technology

Abstract:

We demonstrate optical pump–THz probe (OPTP) spectroscopy with a variable external magnetic field (0–9 T), in which the time-dependent THz signal is measured by echelon-based single-shot detection at a repetition rate of 1 kHz. The method reduces data acquisition times by more than an order of magnitude compared to conventional electro-optic sampling using a scanning delay stage. The approach illustrates the wide applicability of the single-shot measurement approach to non-equilibrium systems that are studied through OPTP spectroscopy, especially in cases where parameters such as magnetic field strength (B) or other experimental parameters are varied. We demonstrate the capabilities of our measurement by performing cyclotron resonance experiments in bulk silicon, where we observe B-field-dependent carrier relaxation and distinct relaxation rates for different carrier types. We use a pair of economical linear array detectors to measure 500 time points on each shot, offering an equivalent performance to camera-based detection with possibilities for higher repetition rates.

Keywords: Electro-optics, Terahertz spectroscopy, Ultrafast measurements, Cyclotron resonance, Ultrafast pump probe spectroscopy

Source:

https://pubs.aip.org/aip/rsi/article/95/3/033005/3270788

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09. Single 3.3 fs multiple plate compression light source in ultrafast transient absorption spectroscopy

Authors: Ronnie R. Tamming, Chao-Yang Lin, Justin M. Hodgkiss, Shang-Da Yang, Kai Chen & Chih-Hsuan Lu

Year: 2021

Faculty/Institution:

- School of Chemical and Physical Sciences, Victoria University of Wellington
- MacDiarmid Institute for Advanced Materials and Nanotechnology, New Zealand
- Robinson Research Institute, Faculty of Engineering, Victoria University of Wellington
- Institute of Photonics Technologies, National Tsing Hua University
- Wellington UniVentures, Victoria University of Wellington
- The Dodd-Walls Centre for Photonic and Quantum Technologies

Abstract:

Ultrafast transient absorption spectroscopy is a powerful tool to reveal excited state dynamics in various materials. Conventionally, probe pulses are generated via bulk supercontinuum generation or (noncollinear) optical parametric amplifiers whilst pump pulses are generated separately using (noncollinear) optical parametric amplifiers. These systems are limited by either their spectral density, stability, spectral range, and/or temporal compressibility. Recently, a new intense broadband light source is being developed, the multi-plate compression, which promises to overcome these limitations. In this paper, we analyze the supercontinuum generated by a single Multiple Plate Compression system to set a benchmark for its use in the field of ultrafast pump-probe spectroscopy. We have compressed the supercontinuum to 3.3 fs using chirp mirrors alone, making it an excellent candidate for pump-probe experiments requiring high temporal resolution. Furthermore, the single light source can be used to generate both probe and pump pulses due to its high spectral density (>14.5 nJ/nm) between 490 and 890 nm. The intensity has an average shot-to-shot relative standard deviation of 4.6 % over 490 to 890 nm, calculated over 2,000 sequential shots. By using only 1,000 shot pairs, a \Delta T/T noise level of 2.6\times 10^{-4} RMS is achieved. Finally, as a proof of concept, the transient absorption spectrum of a methylammonium lead iodide perovskite film is taken, showing great signal to noise with only 1,000 shot pairs. These results show great potential for the employment of this technique in other spectroscopic techniques such as coherent multidimensional spectroscopy.

Source:

https://www.nature.com/articles/s41598-021-92102-5

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10. Resolving individual carrier dynamics with kHz single-shot optical-pump terahertz-probe spectroscopy in high magnetic fields

Authors: Blake S. Dastrup, Peter R. Miedaner, Zhuquan Zhang, Keith A. Nelson

Year: 2024

Faculty/Institution: Massachusetts Institute of Technology

Abstract:

We introduce a novel method of isolating carrier dynamics in optically excited semiconductors using optical-pump terahertz-probe spectroscopy, with a large external magnetic field to isolate different carrier types based on their cyclotron energies. We employ new echelon-based single-shot detection that utilizes a pair of 1D line array detectors which can read out at a 1 kHz repetition rate, reducing acquisition time by more than an order of magnitude. This enables collection of full 2D optical-pump/THz-probe scans at different magnetic fields. We demonstrate these capabilities by performing cyclotron resonance measurements in bulk silicon, and discover distinct carrier dynamics for electrons and holes, as well as their dependence on an external magnetic field.

Source:

https://www.spiedigitallibrary.org/conference-proceedings-of-spie/12870/1287005/Resolving-individual-carrier-dynamics-with-kHz-single-shot-optical-pump/10.1117/12.3005994.short

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11. Lidar thermometry using two-line atomic fluorescence

Authors: Malmqvist, E.; Borggren, J.; Aldén, M.; Bood, J.

Year: 2019

Faculty/Institution:

- Division of Combustion Physics, Department of Physics, Lund University
- Norsk Elektro Optikk Lund AB

Abstract:

In this work, Scheimpflug lidar has been combined with the thermometric technique two-line atomic fluorescence, to carry out stand-off, spatially resolved temperature measurements. Indium atoms were seeded into a modified Perkin-Elmer-burner and two tunable single-mode diode lasers with their wavelengths tuned to 410.17 and 451.12 nm were used to excite the seeded atoms. The fluorescence signal was collected using both a line-scan detector and a two-dimensional intensified CCD camera. One-dimensional flame temperature profiles were measured at different heights above a porous-plug burner, located at a distance of 1.5 m from the lidar system. The technique was also used to demonstrate two-dimensional temperature measurements in the same flame. The accuracy of the measured temperature was found to be limited mainly by uncertainty in the spectral overlap between the laser emission and the indium atom absorption spectrum as well as uncertainty in laser power measurements. With the constraint that indium can be introduced into the measurement volume, it is anticipated that the developed measurement concept could constitute a valuable tool, allowing in situ spatially resolved thermometry in intractable industrial applications, sufferings from limited optical access, thus requiring remote single-optical-port sensing.

Source:

https://lucris.lub.lu.se/ws/portalfiles/portal/119485255/ao_58_4_1128.pdf

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12. Isolating Pure Donor and Acceptor Signals by Polarization-Controlled Transient Absorption Spectroscopy

Authors: Yi Xu, Lars Mewes, Erling Thyrhaug, Vladislav Sláma, František Šanda, Heinz Langhals and Jürgen Hauer

Year: 2023

Faculty/Institution:

- Technical University of Munich, TUM School of Natural Sciences, Department of Chemistry, Professorship of Dynamic Spectroscopy
- Institute of Physics, Faculty of Mathematics and Physics, Charles University
- Department of Chemistry, Ludwig-Maximilians-Universität München

Abstract:

The optical spectra of molecules are often highly congested, inhibiting definite assignment of features and dynamics. In this work, we demonstrate and apply a polarization-based strategy for the decomposition of time-resolved optical spectra to analyze the electronic structure and energy transfer in a molecular donor–acceptor (D–A) dyad. We choose a dyad with orthogonal transition dipole moments for D and A and high fluorescence quantum yield to show that polarization-controlled ultrafast transient absorption spectra can isolate the pure D and A parts of the total signal. This provides a strategy to greatly reduce spectral congestion in complex systems and thus allows for detailed studies of electronic structure and electronic energy transfer.

Source:

https://pubs.acs.org/doi/10.1021/acs.jpclett.3c01451

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