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EDUCATION

Ph.D., Solid State Physics 1999
University of Tartu, Estonia; Supervisor: Professor Jaak Kikas.
Thesis: *Local Relaxation in Incommensurate and Glassy Solids Studied by Spectral Hole Burning.*

M.S., Physics (Optics and Spectroscopy) 1995
University of Tartu.

B.S. (cum laude), Physics (Laser Optics) 1993
University of Tartu.

EMPLOYMENT HISTORY

Assistant Scientist II 2004 – present
Ames Laboratory, USDOE, with Professor Ryszard Jankowiak. Spectral hole burning applied to various photosynthetic pigment-protein complexes. Single molecule- and single complex detection and spectroscopy. Photovoltaic devices based on photosynthetic complexes.

Postdoctoral Research Associate 1999 – 2004
Iowa State University / Ames Laboratory (USDOE), with Professor Gerald J. Small (deceased). Spectral hole burning in photosynthetic complexes. Single molecule- and single complex detection and spectroscopy.

Research Assistant 1994 –1999
Institute of Physics, University of Tartu, Estonia, with Professor Jaak Kikas. Spectroscopy of impurity centers in glasses and molecular crystals, including incommensurate systems; mainly spectral hole burning.

Visiting Research Student Nov. – Dec.
Technical University of Munich, Germany, with Professor Josef Friedrich. 1998

Visiting Research Student April – May
University of Bayreuth, Germany, with Professor Josef Friedrich. 1997

Visiting Student / Research Assistant Sept. – Dec.
Accelerator Laboratory, University of Helsinki, Finland, with Dr. Eero Rauhala. 1996

DISTINCTIONS

Estonian Science Foundation Ph. D. student award(s) (Grant for travel and/or small equipment; 1998, 1999)

MEMBERSHIP

- American Association for the Advancement of Science
- Biophysical Society

RESEARCH EXPERIENCE

Optical spectroscopy of photosynthetic chlorophyll-protein complexes:

- Participated in building an experimental system (based on a confocal microscope) for spectroscopy of single photosynthetic complexes. Performed measurements on single LH-2 and PS-I complexes and single terrylene molecules. Work on various photosynthetic complexes is in progress; the first paper (on cyanobacterial Photosystem I) is submitted to *Photosynthesis Research*.
- Currently participating in development of photovoltaic devices incorporating natural photosynthetic complexes.
- Investigated the properties of the lowest-energy ("red") antenna states of Photosystem I of cyanobacteria using spectral hole burning. First reported the third red antenna state in PS-I of *Synechococcus elongatus,* in addition to two previously described. Applied spectral hole burning in combination with high pressure and electric field to prove that these lowest-energy states originate from strongly coupled chlorophyll aggregates. Matched the aggregates known from structure data to their spectral signatures. Work in progress.
- Applied spectral hole burning to investigate energy transfer and charge separation dynamics in the isolated reaction center of the plant Photosystem II. Developed unified interpretation for results of spectral hole burning, photon echo and pump-probe experiments involving broad distribution of charge separation rates and moderate

electron-phonon coupling for the P680 state. Work on intact oxygen-evolving PS-II cores is in progress.

- Explored inter-pigment interactions and energy transfer processes in the LH-2 antenna complexes of purple bacteria. Combining spectral hole burning with high pressure, investigated the correlation between the magnitudes of excitonic interactions within the B850 ring of bacteriochlorophyll molecules and energy disorder. Obtained pressure-dependent Hamiltonian for the B850 ring. Developed a simple combinatorial model, which qualitatively explains the wavelength dependence of energy transfer rate within the B800 ring.
- Determined Franck-Condon factors for a large number of Bacteriochlorophyll *a* intra-molecular vibration modes. The knowledge of these factors is very important for calculations of the rates of energy transfer in photosynthetic complexes.
- Contributed to research on energy transfer in FMO and CP43 complexes as well as on effects of protein residues on absorption spectra and charge separation in the reaction centers of various mutants of *Rhodobacter Sphaeroides*.

Spectroscopy of impurity centers in glasses and molecular crystals:

- The first application of spectral hole burning and "total luminescence spectroscopy" to the incommensurate system (biphenyl). Explored spectral properties and low-temperature dynamics and their dependence on temperature and pressure, including crossing transitions between incommensurate and commensurate phases. Uncovered various evidence of interaction between (frozen) incommensurate modulation wave and probe molecules.
- Explored anomalies in the hole-burning properties of certain glass/probe molecule combinations. Results were explained within the frame of the models treating glass as a bundle of disclinations, assuming that probe molecules reside preferentially inside these defects. Calculated the absorption spectra of impurity center in free and anchored 1D chains.
- Compared properties of impurity (probe) molecule spectra in crystalline and amorphous phases of *o*-terphenyl at low temperatures.
- Investigated crystallization in overcooled liquids (benzophenone, *o*-terphenyl) and the dependence of inhomogeneous broadening of impurity spectra in molecular crystals on overcooling and crystallization speed.

TECHNICAL EXPERIENCE

Equipment

- Tunable CW dye- and Ti-sapphire lasers, with appropriate pump lasers.
- Various liquid-helium cryostats, including dilution refrigerator.
- Various spectrometers, including Fourier-transform spectrometers.
- System for optical measurements at hydrostatic pressures up to 1200 MPa.
- Single-molecule spectroscopy system based on a confocal microscope, including imaging spectrometer, various objectives, CCD cameras, avalanche photodiodes, etc.

Computers

- C, Visual C++; wrote a program (with J. M. Hayes) for modeling single-site spectra, absorption spectra and spectral hole profiles.
- Mathcad
- Origin, Labcalc, SpectraSolve, WinView, WinSpec and other programs for data acquisition and processing.

OTHER ACADEMIC EXPERIENCES

- Reviewed several manuscripts submitted to the Journal of Luminescence.
- As a postdoctoral associate supervised research of graduate and undergraduate students.
- Participated in the PFF (Preparing Future Faculty) program at ISU (GR ST 585, 586)
- Gave private lessons in physics and chemistry to high school students.

PUBLICATIONS (with citation index calculated **not** counting citations in papers I co-authored)

1. Emission Spectra of Single Photosystem I Complexes from Cyanobacterium *Synechocystis* PCC 6803, K. Riley, T. Reinot, T.-M. Hsin, R. Jankowiak and **V. Zazubovich**, submitted to *Photosynthesis Research* (2004).

2. Red Antenna States of PS I of Cyanobacteria: Stark Effect and Interstate Energy Transfer, T.-M. Hsin, **V. Zazubovich**, J. M. Hayes, and G. J. Small, *J. Phys. Chem.* B 108 (2004) 10515.

3. Evidence for Highly Dispersive Primary Charge Separation Kinetics and Gross Heterogeneity in the Isolated PS II Reaction Center of Green Plants, K. Riley, R. Jankowiak, M. Rätsep, G. J. Small, and **V. Zazubovich**, *J. Phys. Chem*. B 108 (2004) 10346.

4. Effects of Ionizable Residues on the Absorption Spectrum and Initial Electron-transfer Kinetics in the Photosynthetic Reaction Center of *Rhodobacter sphaeroides,* E. T. Johnson, V. Nagarajan, **V. Zazubovich**, K. Riley, G. J. Small, W. W. Parson, *Biochemistry*, 42 (2003) 13673. 1

5. Pressure Effects on the Spectra of Dye Molecules in Incommensurate and Commensurate Phases of Biphenyl, **V. Zazubovich**, A. Suisalu, K. Leiger, A. Laisaar, An. Kuznetsov, J. Kikas, *Chem. Phys*. 288 (2003) 57. 2

6. How Fast is Excitation Energy Transfer in the Photosystem II Reaction Center in the Low Temperature Limit: Hole Burning vs. Photon Echo, **V. Zazubovich**, R. Jankowiak, K. Riley, R. Picorel, M. Seibert and G. J. Small, *J. Phys. Chem*. B 107 (2003) 2862. 2

7. The Primary Charge Separation Rate at 5 K in Isolated Photosystem II Reaction Centers Containing 5 and 6 Chlorophyll *a* Molecules, R. Jankowiak, M. Rätsep, J. M. Hayes, **V. Zazubovich,** R. Picorel, M. Seibert and G. J. Small, *J. Phys. Chem.* B 107 (2003) 2068. 2

8. A High-Pressure Spectral Hole Burning Study of Correlation between Energy Disorder and Excitonic Couplings in the LH2 Complex from *Rhodopseudomonas Acidophila*, **V. Zazubovich,** R. Jankowiak and G. J. Small, *J. Phys. Chem.* B 106 (2002) 6802. 6

9. On B800 → B800 Energy Transfer in the LH2 Complex of Purple Bacteria, **V. Zazubovich,** R. Jankowiak and G .J. Small, *J. Lumin.* 98 (2002) 123. 4

10. Red Antenna States of Photosystem I from Cyanobacterium *Synechococcus elongatus*: a Spectral Hole Burning Study, **V. Zazubovich**, S. Matsuzaki, T. W. Johnson, J. M. Hayes, P. R. Chitnis and G. J. Small, *Chem. Phys.* 275 (2002) 47. 24

11. Bacteriochlorophyll *a* Franck-Condon Factors for the $S_0 \rightarrow S_1$ (Q_y) Transition, **V. Zazubovich,** I. Tibe and G. J. Small, *J. Phys. Chem.* B 105 (2001) 12410. 2

12. Irreversible Dynamics in Incommensurate Biphenyl Studied by Thermocycling of Spectral Holes, **V. Zazubovich,** A. Suisalu and J. Kikas, *Phys. Rev.* B 64 (2001) 104023. 2

13. Energy Transfer Dynamics in LH2 Complexes of *Rhodopseudomonas acidophila* Containing Only One B800 Molecule, S. Matsuzaki, **V. Zazubovich**, N. J. Fraser, R. J. Cogdell and G. J. Small, *J. Phys. Chem.* B 105 (2001) 7049. 5

14. New Insights on Persistent Nonphotochemical Hole Burning and Its Application to Photosynthetic Complexes, T. Reinot, **V. Zazubovich,** J. M. Hayes and G. J. Small, *J. Phys. Chem.* B 105 (2001) 5083 (Feature Article). 15

15. The CP43 Core Antenna Complex of Photosystem II Possesses Two Quasi-Degenerate and Weakly Coupled Q_y-Trap States, R. Jankowiak, **V. Zazubovich,** M. Rätsep, S. Matsuzaki, M. Alfonso, R. Picorel, M. Seibert and G. J. Small, *J. Phys. Chem*. B 104 (2000) 11805. 10

16. Energy Transfer Kinetics and Low Energy Vibrational Structure of the Three Lowest Energy Q_y-States of the Fenna-Matthews-Olson Antenna Complex, S. Matsuzaki, **V. Zazubovich,** M. Rätsep, J. M. Hayes and G. J. Small, *J. Phys. Chem.* B 104 (2000) 9564. 5

17. Elastic Scattering Cross Sections of Protons by Copper, Molybdenum, Silver and Tin near the Coulomb Barrier, A. Nurmela, **V. Zazubovich**, J. Räisänen, E. Rauhala and R. Lappalainen, *J. Appl. Phys.* 84 (1998) 1796. 4

18. Low-Temperature Dynamics of Incommensurate Biphenyl as Probed by Spectral Hole Burning, J. Kikas, A. Suisalu, **V. Zazubovich**, J. Friebel and J. Friedrich, *Europhysics Letters* 44 (1998) 613.	4
19. Anomalous Hole Spectra in Glasses: a Case for 1D Dynamics? J. Kikas, A.Suisalu and **V. Zazubovich**, *J. Lumin.* 76/77 (1998) 615.	
20. Anomalous Hole Spectra in Chlorin-Doped Low-Temperature Glasses, J. Kikas, A. Suisalu and **V. Zazubovich**, *Mol. Cryst. Liq. Cryst.* 291 (1996) 215.	
21. Anomalous Impurity Spectra in Low Temperature Glasses, J. Kikas, A. Suisalu, **V. Zazubovich** and P. Vois, *J. Chem. Phys*. 104 (1996) 4434.	2
Total	90

MAJOR PRESENTATIONS

- PS-2004 Light-Harvesting Systems Workshop (St.-Adele, Quebec, Canada, 2004, poster and short oral presentation) *Evidence for Highly Dispersive Primary Charge Separation Kinetics and Gross Heterogeneity in the Isolated PS II Reaction Center of Green Plants.*
- ESP-2003 (Los Alamos, New Mexico; 2003, oral presentation) *Dispersive Kinetics of Primary Charge Separation in the Isolated Reaction Center of Photosystem II Studied with Spectral Hole Burning.*
- HBSM-2003 (Bozeman, Montana; 2003, poster) *Correlation Between Energy Disorder and Excitonic Couplings in the LH 2 Complex from Rhodopseudomonas Acidophila. (A High Pressure Spectral Hole Burning Study.)*
- EPS-11 (London, UK; 1999; poster) *Hole Burning Spectroscopy of Incommensurate Biphenyl.*
- Jyväskylä 8-th International Physics Summer School (Jyväskylä, Finland, 1998; oral presentation). *Spectral Hole Burning Study of Incommensurate Biphenyl.*
- DPC-97 (Kleinwalsertal, Austria, 1997; poster). *Anomalous Hole Spectra in Glasses: a Case for 1D dynamics?*

REFERENCES

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