Summary of professional accomplishments, list of publications and intomation on teaching, scientific cooperation and popularization

1. Name: Wojciech Wasilewski

2. Diplomas held:

Doctoral degree in physical sciences in the field of physics, specialization: quantum optics,
Awarded by the Council of the Faculty of Physics, Astronomy and Applied Computer Science,
Nicolaus Copernicus University in Toruń on 12/12/2007
Thesis title: "Sources of photons in quantum communication"

3. Information about previous emplyment
Since 2008: Assistant Professor at the Faculty of Physics, University of Warsaw
2008-2009: Postdoc, Niels Bohr Institute, Copenhagen

4. Indication of achievement resulting from art. Paragraph 16. 2 of the Act of 14 March 2003. Of academic degrees and academic titles and degrees and Title in Art (Journal. Laws No. 65, item. 595, as amended.):

A) title of the scientific achievment:
Monothematic series of publications entitled "Development of the controlled Raman scattering as a mean to generate, store and retrieve states of light"

B) list of publictations constituting (A)

1. Jan Kołodyński, Jan Chwedeńczuk, Wojciech Wasilewski, Eigenmode description of Raman scattering in atomic vapors in the presence of decoherence, Phys. Rev. A 86, 013818 (2012)
contribution of the applicant: design of work, coordination of work, parts of the calculations, about 45%
2. R. Chrapkiewicz, W. Wasilewski, Generation and delayed retrieval of spatially multimode Raman scattering in warm rubidium vapors, Opt. Express 20, 29540-29552 (2012)
contribution of the applicant: design of work, setup construction, coordination of work, part of experiment and data analysis: about 64%
3. M. Parniak-Niedojadło, W. Wasilewski, Direct observation of atomic diffusion in warm rubidium ensembles, Appl. Phys. B
contribution of the applicant: design of work, coordination of work, about 41%
4. Radoslaw Chrapkiewicz, Wojciech Wasilewski, Czesław Radzewicz, How to measure diffusional decoherence in multimode Rubidum vapor memories?
contribution of the applicant: design of work, coordination of work, part of experiment and data analysis: about 47%
5. Michał Dąbrowski, Radosław Chrapkiewicz, Wojciech Wasilewski, Hamiltonian design in readout from room-temperature Raman quantum memory,
contribution of the applicant: design of work, theory model, coordination of work, about 35%

C) discussion of the scientific goal of aforementioned works, achieved results and potential applications.

Series of publications describe the construction of the experimental setup and the development of

the theoretical model of creation, storage and retrieval of quantum excitations using controlled collective Raman scattering in rubidium vapor. They document the first stages of research which is aimed at demonstrating that we are able to use many independent (pseudo) spin waves generated simultaneously in a cell with rubidium vapor at room temperature to generate simple multiphoton states.
The Raman scattering can be utilized to prepare the collective excitation of atoms (spin waves). After storage, a second Raman scattering act can convert spin waves to optical photons.

Creation of the spin wave is a two stage process utilizing two chosen states of hyperfine structure of the ground state, for instance F=1 and F=2, $m_F=0$ of Rubidium 87. At the first stage atoms in the cell are optically pumped into F=1 state. Next a pencil-shaped region in the cell is illumined with a laser pulse driving spontaneous Raman scattering. With proper choice of beam diameter and pulse energy (about 1us, 1cm, 1mW, 1GHz detuning) single acts of scattering can be induced. Each of them produces a pair: scattered photon which can be registered and single atomic excitation to F=2 state.

Series of publications focuses on non-collinear scattering, when a photon is emitted at an angle to driving laser beam. Then the act of scattering involves transfer of momentum to atoms which enter a coherent superposition state. One of them is excited to F=2 but it could be anyone. The transferred momentum $\hbar K$ is encoded in phase relations between atoms in various places of the cell. This state is called spin wave. It is created conditioned on observation of scattered photon. The location of the scattered photon on the camera placed in the far field enables inferring the transferred momentum $\hbar K$.

Unique advantage of the above method of creating the quantum excitations is the time available to process it while it is stored immobile in the atomic ensemble. Depending on the measured value of the transferred momentum $\hbar K$ different steps can be undertaken, for example the direction of the laser beam used subsequently can be altered.

The spin wave can be converted back to light using second laser pulse. This process also conserves momentum meaning that the direction of produced photon can be precisely foreseen or altered.

Within the series of publication presented I developed those concepts both theoretically and experimentally.

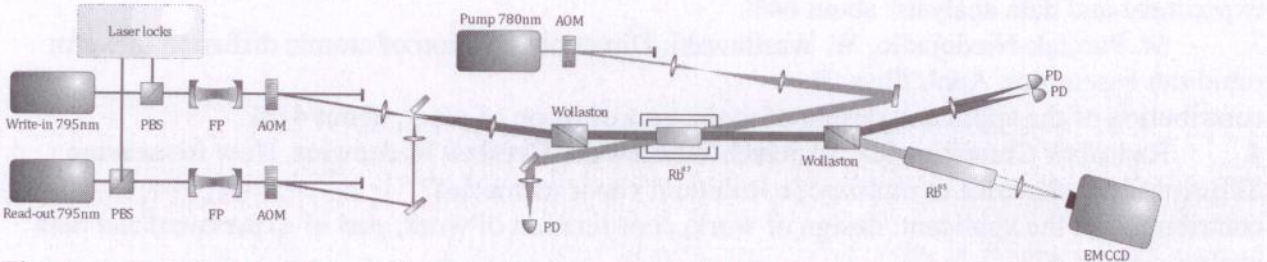

Figure 1. Experimental setup of qumantum memory with Raman interface . Pump laser pumps atom sinto F=1 state. Next, the write laser induces raman transitions to F=2 state with simulataneous emmision of Stokes photons registered at CCD camera. Finally the read laser converts atomic excitations into anti-Stokes photons.
Driving lasers are filtered with Fabry-Perot cavities dither locked for minimal reflection. Scattered light is filtered by a polarizer and through a Rb-85 cell placed in magnetic field. Pulses are shaped with AOM modulators.

The experimental setup we use is depicted in Fig. 1. It was built mostly by myself at the Institute of Experimental Physics, University of Warsaw.
Registering weak scattered light necessitates use of proper technical means. Driving lasers were filtered by resonant cavities of Finesse about 50 to reduce the ASE background. Scattered photons for large detuning of drive lasers from excited state manifold are emitted with polarization perpendicular to the drive beams. This enables attenuating the laser light by a factor of about 10^5 using crystal polarizers. Additional 6 orders of magnitude attenuation is obtained passing scattered light trough vapor cell containing 85-Rb in perpendicular magnetic field.
Pulse sequence is timed using FPGA card running custom made finite state machine. It executes a pseudocode prepared for each sequence type on a PC with LabVIEW interface. FPGA drives Direct Digital Synthesizers (AD9959 chips on homemade boards) which provide signels for AOM modulators. This enables precise and very fast beam modulation including frequency modulation and enabling beam steering. In addition FPGA can provide large number of custom triggers, now used for oscilloscope, camera and image intensifier. Temporal step of FPGA is currently 12.5ns but can be improved if necessary.
Write laser is stabilized with DAVLL scheme[1], ie. the error signal comes from Faraday effect. It is measured with a homemade balanced pair of photodiodes integrated with polarizer. Differential signal is fed to PI/lowpass analog loop which provides feedback for the laser current and grating position. The loop is enabled digitally and equipped with a microcontroller (STM32) which can scan the laser and digitized spectroscopy signals. Same microcontroller stabilizes filter cavity. Such a combination enables concurrent scanning of both devices useful for both laser setpoint optimization and frequency scanning of the filtered beam. Control is exercised through LabVIEW interface.
The read laser is interfered with the write on a microwave photodiode and the beatnote is sent to phase and frequency comparator equipped with suitable dividers. Its output is sent to the laser through suitable feedback loop[2]. In a fashion similar to the write laser, microcontroller controls the loop and stabilizes the filtering cavity.

Let me now proceed with the description of each publication from the series.

In the article [1] we constructed simplified theoretical model of the Raman atom-light interface. In the approximation of low number of created excitations the description of the full 3-dimensional ensemble of atoms interacting with light field propagating trough it can be simplified by virtually contracting the system along the direction of propagation of light down to zero thickness. This enables eliminating nontrivial dependencies on the spatial coordinate along the propagation of light. Then the mode basis of the light field and the mode basis of the atomic excitations (spin waves) can be so chosen as to bring the light-atoms interaction into simple form. Each light mode is paired with atomic mode and they interact only within each pair, without any coupling between distinct pairs. The mode functions for light form orthonormal set and so the mode functions for atoms. This approximation dramatically simplifies understanding of complicated spatio-temporal phenomena by separating spatial from temporal degrees of freedom. Equations of evolution for each pair of coupled modes take on a simple form of two-mode squeezing in a lossy cavity. This enables simple calculation of experimentally important quantitites. It also enables simple inclusion of atomic decoherence or subsequent action of more than one type of Raman scattering. The developed model enable interpretation of experimental results while in lab, without tedious computations.

In the article [2] we demonstrated the possibility of storage of multimode states of spin waves. By

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[1] Dichroic atomic vapour laser lock, np. Kristan L. Corwin, Zheng-Tian Lu, Carter F. Hand, Ryan J. Epstein, and Carl E. Wieman, "Frequency-stabilized diode laser with the Zeeman shift in an atomic vapor" Appl. Opt. 37, 3295 (1998).

[2] J. Appel, A. MacRae, and A. Lvovsky "versatile digital Ghz phase lock for external cavity diode lasers", Measurement Science and Technology 20 (2009)

measuring intensity correlations between Stokes and anti-Stokes scattered light we have shown that the spinwaves carry few spatial modes. Unfortunately higher ones decay almost instantaneously due to diffusion. We have also measured the dynamics of the creation of atomic excitations in various buffer gasses. The results qualitatively agree with theoretical model of [1], however a number of discrepancies appear. They likely result from pressure broadening or other more involved decoherence mechanism activated by laser illumination.

In the article [3] we used the methods developed above for a precise measurement of spinwave decoherence in the absence of light i.e. during storage in quantum memory. If multiple spatial spinwave modes are to be utilized the dominant decoherence mechanism is diffusion of atoms in the buffer gas. The numerical values of the diffusion coefficients quoted in literature are widely scattered likely due to involved way they were measured which was typically 40 years ago. Therefore we decided it would be worthwhile to publish a method relying on modern tools widely accessible nowadays. The method enables quantifying diffusion in any single sealed cell, within pressure range that allows for observation of the Raman scattering. The method is based on calculating the spinwave decay rate by measuring the readout signal as a function of storage time. Spinwaves with large wavevector K are characterized by fast spatial variation of the phase of coherence between the ground states and thus easily decohere due to random movements of the atoms as they diffuse in the buffer gas. As this process continues the ground state coherence is spatially averaged, only zero-K wavevector spinwave survives and the only forward scattering is observed.
The dependence of the decay rate on the scattering angle and thus the spinwave wavevector K is found by observing the readout in the far field on a camera. A square dependence of the decay rate on the K vector length reassures proper measurement.

Due to the high importance of the decoherence process and the necessity of its precise characterization we developed an independent method to measure the diffusion coefficients based on observation of the spreading of initially localized optically pumped population imbalance in the cell [4]. This is a particularly simple concept. With a pulsed pump beam focused to a fraction of a millimeter we locally pump atoms to ground state of F=1. After a variable temporal delay we illuminate the entire cell tuned to F=1 → F'=2 transition and we image the shadow of pumped atoms onto a camera. Fourier analysis of the optical depth images enables calculating the decay time for various Fourier components. Final data processing follows the same trail as in prior method. Note however, that this method probes the population distribution, not the coherence and can be performed with high buffer gas pressure forbidding Raman scattering.

Using methods presented in [3] and [4] we confirmed some literature values. Both methods gave practically same results. In addition we measured the diffusion of Rubidium in Xenon for the first time directly. This result may help in recently popular biomedical imaging with hyperpolarized Xenon, which is obtained in spin exchange collisions with optically polarized rubidium.

In the article [5] we used prior results to demonstrate the possibility of engineering the Hamiltonian of interaction between light and atoms in the Raman scattering process. In a multilevel atom, such as Rubidium, typically the same laser beam of given frequency an polarization can drive both the Stokes transition shifting the atom to an empty F=2 state and well as anti-Stokes transition shifting atom back to F=1 state. This results in an interaction more involved than pure readout (anti-Stokes) or write-in (Stokes) which acting one at a time result in either conversion of spinwaves to photons or generation of excitation pairs. In particular the laser can be easily tuned to drive both transitions equally. Then the interaction between the atoms and light is of quantum non demolition or QND type which enables partial measurement of single spinwave quadrature at the expense of of accumulation of shot noise in a conjugate quadrature. Alternatively if the anti-Stokes dominates, the resultant interaction can be understood as a exchange of excitations between light and spinwave

fields with simultaneous single mode squeezing of each field right after exchange. The degree of squeezing is determined by relative contribution of Stokes coupling.
In the article [5] we measured intensity hallmarks of coexistence of Stokes and anti-Stokes transitions. Firstly these interactions determine the dynamics of scattering. The domination of the anti-Stokes process is characterized by an exponential decay indicating readout of excitations from spinwave to the light field and decay of the former. On the contrary the domination of the Stokes process leads to exponential rise of spinwave and with it the scattered light intensity in time. Secondly the contributions of various processes to the scattering can be estimated by measuring intensity correlations between portions of the light scattered in properly chosen directions. This is accomplished by sending two drive pulses at slightly different angles through the atomic vapor cell. First is detuned so that it drives predominantly Stokes scattering and leads to production of photon-spinwave pairs. The second pulse frequency is adjusted and the contributions of the Stokes and anti-Stokes processes induced by it are quantified. Note that in this configuration each spinwave with wave vector K is coupled to three photon modes. For instance let K point right. The photons scattered during first pulse heralding creation of the excitations in chosen spinwave would be scattered to the left of the first drive beam. In turn during the second laser pulse the Stokes scattered photons will launch to the left of the second drive beam while the anti-Stokes scattered photons to the right. Those relations enable distinguishing of those fields on a camera in the far field. The number of spinwave excitations created in any iteration of the experiment is random drawn from a thermal statistics. However it is tightly correlated to the number of Stokes photons scattered in the first pulse. By measuring the intensity covariance between points where the photons from the first and second pulse coupled to the same spinwave fall on the camera the contributions of respective scattering processes to the total flux can be calculated by proper statistical analysis.
In summary the article [5] demonstrates the broad extend in which the contributions of Stokes and anti-Stokes scattering to the 4WM (4-wave mixing) can be adjusted. Our results may inspire theoretical development of quantum communication protocols as they indicate an easy way to implement a class of atom-light interactions much broader that typically assumed available. In addition we provide straightforward ways to estimate the decoherence encountered in typical experiments and hence order the protocols with respect to ease of actual implementation.

The results contained in the significant achievement described herein constitute a firm base for further experiments with quantum memories. The next step is technically difficult and involves finding a way to attenuate the parasitic scattering processes so that true single scattered photons can be registered and nonclassical states of light produced. Till now no other group has been successful reaching this goal. Should any of currently tested photon filters be successful, a novel, very interesting research paths will be unclogged. The worm atomic memories are but the simplest to make and thus worth the effort to subjugate a multitude of parasitic effects which nowadays preclude the implementation of the most interesting ideas.

5. List of other scientific achievments, not contributing to point 4 above, including publishe works and bibliometric data

A. Scientific publications in journals listed in Journal Citation Reports (JRC) database

i. achivements before obtaining PhD
I began my scientific career uder direction of prof. Czesław Radzewicza at the Department of Physics, University of Warsaw in 2000. I took part in experimentl investigations of intense femtosecond pulse propagation in glasses [A20] as well as in developing methods for generation, shaping and characterization of ultrashort pulses of light [A9, A10, A13, A15, A16], partly in cooperation with prof. Ian Walmsley of Oxford. In parallel I developed computational and theory skills under supervision of prof. Marek Trippenbach taking part in nonlinear optics projects [A17,

A18, A19]. These days I also enjoyed cooperation with prof. Maciej Wojtkowski [A11, A12]. With time my interest shifted toward quantum optics. As the country-wide AMO physics lab (KL FAMO) was founded in Toruń I enjoyed an opportunity to participate in a project there [A14].
Next I moved to Toruń for a PhD under supervision of prof. Konrad Banaszek. We found a canonical representation for quantum states of light generated in realistic parametric amplifiers [A5, A6, A7] and we developed methods for their engineering and utilization in quantum communication [A4]. In parallel we developed novel methods of photon source characterization [A1, A3, A8] as well as ultrashort pulse characterization methods tailored for pulses driving photon sources [A2].

A1. Wojciech Wasilewski, Czesław Radzewicz, Robert Frankowski and Konrad Banaszek *Statistics of multiphoton events in spontaneous parametric down-conversion* Phys. Rev. **A 78**, 033831 (2008). Contribution of the applicant: devising the method, data analysis, measurements, software, manuscript preparation, about 70%

A2. M. Kacprowicz, W. Wasilewski and K. Banaszek, *Complete characterisation of weak, ultrashort near-UV pulses by spectral interferometry*, Appl. Phys. **B 91**, 283-286 (2008). Contribution of the applicant: idea, calculations, supervision of experiment, manuscript preparation, about 40%

A3. W. Wasilewski, P. Kolenderski and R. Frankowski, *Spectral density matrix of a single photon measured*, Phys. Rev. Lett. **99**, 123601 (2007), Contribution of the applicant: idea, calculations, supervision of experiment, manuscript preparation, about 75%

A4. W. Wasilewski and K. Banaszek, *Protecting an optical qubit against photon loss*, Phys. Rev. A 75, 042316 (2007). Contribution of the applicant: calculations, participation in manuscript preparation, about 70%

A5. A. I. Lvovsky, Wojciech Wasilewski, Konrad Banaszek, *Decomposing a pulsed optical parametric amplifier into independent squeezers*, J. Mod. Opt. 54, 721-733 (2007). Contribution of the applicant: calculations, result interpretation, participation in manuscript preparation, about 50%

A6. Wojciech Wasilewski, A. I. Lvovsky, Konrad Banaszek, Czeslaw Radzewicz, *Pulsed squeezed light: simultaneous squeezing of multiple modes*, Phys. Rev. A 73, 063819 (2006). Contribution of the applicant: calculations, result analysis, participation in manuscript preparation, about 67%

A7. Wojciech Wasilewski, M. G. Raymer, *Pairwise entanglement and readout of atomic-ensemble and optical wave-packet modes in traveling-wave Raman interactions*, Phys. Rev. A 73, 063816 (2006). Contribution of the applicant: calculations, result analysis, manuscript preparation, about 80%

A8. Wojciech Wasilewski, Piotr Wasylczyk, Piotr Kolenderski, Konrad Banaszek, Czeslaw Radzewicz, *Joint spectrum of photon pairs measured by coincidence Fourier spectroscopy*, Opt. Lett. 31, 1130 (2006). Contribution of the applicant: idea, preparation and measurements, participation in manuscript preparation, about 60%

A9. A. S. Radunsky, E. M. Kosik Williams, I. A. Walmsley, P. Wasylczyk, W. Wasilewski, A. B. U'Ren, M. E. Anderson, *Simplified Spectral Phase Interferometry for Direct Electric-Field Reconstruction using a thick nonlinear crystal*, Opt. Lett. 31, 1008 (2006). Contribution of the applicant: participation in measurements, about 10%

A10. Piotr Wasylczyk, Ian A. Walmsley, Wojciech Wasilewski, Czesław Radzewicz, *A broadband noncollinear optical parametric amplifier using a single crystal*, Opt. Lett. **30**, 1704 (2005). Contribution of the applicant: theoretical model, participation in measurements, participation in manuscript preparation, about 30%

A11. Maciej Szkulmowski, Maciej Wojtkowski, Tomasz Bajraszewski, Iwona Gorczynska, Piotr Targowski, Wojciech Wasilewski, Andrzej Kowalczyk and Czesław Radzewicz, *Quality improvement for high resolution in vivo images by Spectral domain optical coherence tomography with supercontinuum source*, Optics Comm. **246**, 569 (2005). Contribution of the applicant: participation in measurements, about 10%

A12. Maciej Wojtkowski, Tomasz Bajraszewski, Iwona Gorczynska, Piotr Targowski, Andrzej Kowalczyk, Wojciech Wasilewski and Czeslaw Radzewicz, *Ophthalmic Imaging by Spectral Optical Coherence Tomography*, Am. J. Ophthalmol. 138, 412–419 (2004). Contribution of the applicant: participation in measurements, about 10%

A13. Piotr Wasylczyk, Wojciech Wasilewski, Czeslaw Radzewicz, *A single-shot autocorrelator based on a Babinet compensator*, Rev. Sci. Instr. 75, 2482-2484 (2004). Contribution of the applicant: participation in measurements, participation in manuscript preparation, about 30%

A14. K. Banaszek, A. Dragan, W. Wasilewski, C. Radzewicz *Experimental demonstration of entanglement-enhanced classical communication over a quantum channel with correlated noise*, Phys. Rev. Lett. 92, 257901 (2004). Contribution of the applicant: participation in experimental preparations and measurements, about 30%

A15. W. Wasilewski, P. Wasylczyk, C. Radzewicz, *Femtosecond laser pulses measured with a photodiode - FROG revisited*, Appl. Phys. B **78**, 589-592 (2004). Contribution of the applicant: participation in experimental preparations and measurements, data analysis, theoretical model, about 60%

A16. C. Radzewicz, P. Wasylczyk, W. Wasilewski, J. S. Krasiński *Piezo-driven deformable mirror for femtosecond pulse shaping*, Opt. Lett. 29, 177 (2004). Contribution of the applicant: participation in measurements, data analysis, software, about 30%

A17. Michal Matuszewski, Wojciech Wasilewski, Marek Trippenbach and Y. B. Band, *Self-consistent treatment of the full vectorial nonlinear optical pulse propagation equation in an isotropic medium*, Opt. Comm. **221**, 337 (2003). Contribution of the applicant: part of calculations, participation in manuscript preparation, about 40%

A18. M. Trippenbach, W. Wasilewski, P. Kruk, G. W. Bryant, G. Fibich, Y. B. Band, *An Improved Nonlinear Optical Pulse Propagation Equation*, Optics Comm. **210**, 385 (2002). Contribution of the applicant: part of calculations, participation in manuscript preparation, about 35%

A19. W. Wasilewski, M. Trippenbach, K. Rzążewski, *Bose-Einstein condensates in optical lattices*, Acta Physica Polonica **101**, 47 (2002). Contribution of the applicant: numerical modeling, participation in manuscript preparation, about 55%

A20. P. Wasylczyk, W. Wasilewski, M. Trippenbach, C. Radzewicz, *Nonlinear Effects with Ultrashort Laser Pulses*, Acta Physica Polonica **101**, 89 (2002). Contribution of the applicant: numerical modeling, participation in experiment and manuscript preparation, about 35%

ii. achievements after obtaining PhD

After finishing my PhD I was employed at the Department of Physics University of Warsaw and I conducted a number of projects based on pre-PhD ideas to foresee the behavior of parametric amplifiers of ultrashort pulses of light, in particular their noise performance [A27, A35]. I also took part in finishing theoretical works concerning photon pair sources [A26, A31, A33] and in theoretical and experimental works on quantum-enchanced measurements [A24, A29, A32, A34]. I also decided to switch to completely different photon sources, that is controlled collective Raman scattering which on paper possess irresistible charm. To familiarize myself with completely different experimental techniques I went for a postdoc to prof. Polzik to Copenhagen. There I have achieved my goal [A25] working on the single mode quantum memories operated in the continuous variable regime. We managed to significantly improve the theoretical models [A30] which fruited in a number of articles demonstrating novel and interesting effects [A21, A23, A28].

A21. R. Chrapkiewicz, W. Wasilewski, K. Banaszek , *High-fidelity spatially resolved multiphoton* *counting for quantum imaging applications,* Opt. Lett. 39, 5090 (2014). Contribution of the applicant: preparation of the experimental apparatus, consultations, about 15%

A22. H. Krauter, C. A. Muschik, K. Jensen, W. Wasilewski, J. M. Petersen, J. I. Cirac and E. S. Polzik, *Entanglement Generated by Dissipation and Steady State Entanglement of Two Macroscopic Objects*, Phys. Rev. Lett. 107, 080503 (2011). Contribution of the applicant: preparation of the experimental apparatus and software, about 15%

A23. K. Jensen, W. Wasilewski, H. Krauter, T. Fernholz, B. M. Nielsen, A. Serafini, M. Owari, M. B. Plenio, M. M. Wolf, E. S. Polzik, *Quantum memory for entangled continuous-variable states,* Nature Physics **7**, 13-16 (2011). Contribution of the applicant: preparation of the experimental apparatus and software, part of the theoretical model, supervision and part of the measurements, data analysis, about 45%

A24. Tomasz Wasak, Piotr Szańkowski, Wojciech Wasilewski, and Konrad Banaszek, *Entanglement-based signature of nonlocal dispersion cancellation*, Phys. Rev. A 82, 052120 [5 pages] (2010). Contribution of the applicant: consultations, about 5%

A25. M. V. Balabas, K. Jensen, W. Wasilewski, H. Krauter, L. S. Madsen, J. H. Müller, T. Fernholz, and E. S. Polzik *High quality anti-relaxation coating material for alkali atom vapor cells*, Opt. Express 18, 5825-5830 (2010). Contribution of the applicant: preparation of the experimental apparatus and software, participation in the measurements, about 12%

A26. Radoslaw Chrapkiewicz, Wojciech Wasilewski, *Multimode Spontaneous Parametric Down-Conversion in the Lossy Medium,* J. Mod. Opt. 57, 345-355 (2010). Contribution of the applicant: idea, supervision, manuscript preparation, about 30%

A27. Piotr Migdał, Wojciech Wasilewski, *Noise reduction in 3D noncollinear parametric amplifier,* Appl. Phys. B. 99, 657-671 (2010). Contribution of the applicant: idea, supervision, manuscript preparation, about 30%

A28. W. Wasilewski, K. Jensen, H. Krauter, J.J. Renema, E.S. Polzik, *Quantum Noise Limited and Entanglement-Assisted Magnetometry,* Phys. Rev. Lett. 104, 133601 (2010). Contribution of the applicant: participation in planning and measurements, data analysis, theoretical model, participation in manuscript preparation, about 45%.

A29. M. Kacprowicz, R. Demkowicz-Dobrzanski, W. Wasilewski, K. Banaszek, I. A. Walmsley, *Experimental quantum-enhanced estimation of a lossy phase shift* Nat. Photon. 4, 357 - 360 (2010). Contribution of the applicant: preparation of the experimental apparatus and experiment, consultation, about 5%

A30. W. Wasilewski, T. Fernholz, K. Jensen, L. S. Madsen, H. Krauter, C. Muschik and E. S. Polzik *Generation of two-mode squeezed and entangled light in a single temporal and spatial mode*, Opt. Express **17**, 14444-14457 (2009). Contribution of the applicant: participation in planning and measurements, data analysis, theoretical model, participation in manuscript preparation, about 50%.

A31. Piotr Kolenderski, Wojciech Wasilewski *Derivation of the density matrix of a single photon produced in parametric down-conversion* Phys. Rev. A **80**, 015801 (2009). Contribution of the applicant: consultation, about 15%

A32. R. Demkowicz-Dobrzanski, U. Dorner, B. J. Smith, J. S. Lundeen, W. Wasilewski, K. Banaszek, I. A. Walmsley *Quantum phase estimation with lossy interferometers* Phys. Rev. A 80, 013825 (2009). Contribution of the applicant: consultation, about 5%

A33. Piotr Kolenderski, Wojciech Wasilewski, Konrad Banaszek *Modelling and optimization of photon pair sources based on spontaneous parametric down-conversion* Phys. Rev. A 80, 013811 (2009). Contribution of the applicant: consultation, about 10%

A34. U. Dorner, R. Demkowicz-Dobrzanski, B. J. Smith, J. S. Lundeen, W. Wasilewski, K. Banaszek, I. A. Walmsley *Optimal Quantum Phase Estimation* Phys. Rev. Lett._**102**, 040403 (2009). Contribution of the applicant: consultation, about 5%

A35. Jan Chwedeńczuk, Wojciech Wasilewski *Intensity of parametric fluorescence pumped by ultrashort pulses*, Phys. Rev._**A 78**, 063823 (2008)._Contribution of the applicant: idea, work planning, manuscript preparation, about 30%

B. Inventions, utility models, patents, etc.
R. Chrapkiewicz i W. Wasilewski: „Przestrajalny, wąskopasmowy filtr optyczny do filtrowania wiązek laserowych i sposób filtrowania wiązek laserowych" (tunable, narrowband optical filter for filtering laser beams and method for filtering laser beams) no.: [WIPO ST 10/C PL408059]; Patent application filled in on 29.04.2014, Patent office of Poland. Contribution of the applicant: preparation of experimental apparatus, consultations, about 30%

C. Monographs, publications in Polish or international journals not listed in points 5A or 5B:

C1. Michał Dąbrowski, Michał Parniak, Daniel Pęcak, Radosław Chrapkiewicz, Wojciech Wasilewski, *Spontaneous and parametric processes in warm rubidium vapours*, accepted for publication in Latvian Journal of Physics and Technical Sciences. Contribution of the applicant: preparation of experimental apparatus, consultations, about 15%

C2. K. Jensen, W. Wasilewski, H. Krauter, T. Fernholz, B. M. Nielsen, J. M. Petersen, J. J. Renema, M. V. Balabas, M. Owari, M. B. Plenio, A. Serafini, M. M. Wolf, C. A. Muschik, J. I. Cirac, J. H. Muller and E. S. Polzik, *Quantum memory, entanglement and sensing with room temperature atoms,* J. Phys.: Conf. Ser. **264** 012022, (2011). Contribution of the applicant: participation in planning and measurements, preparation of experiment and software, theoretical model, about 30%

C3. K. Jensen, W. Wasilewski, H. Krauter, J. J. Renema, M. V. Balabas and E. S. Polzik, *Quantum noise limited and entanglement-assisted magnetometry,* Lasers and Electro-Optics (CLEO) and Quantum Electronics and Laser Science Conference (QELS), (2010). Contribution of the applicant: participation in planning and measurements, preparation of experiment and software, theoretical model, about 30%

C4. M. Kacprowicz, W. Wasilewski, R. Demkowicz-Dobrzanski, K. Banaszek, *Interferometric phase measurement with two-photon states*, Lasers and Electro-Optics 2009 and the European Quantum Electronics Conference, CLEO Europe - EQEC 2009. Contribution of the applicant: participation in planning and measurements, preparation of experiment and software, about 10%

C5. R. Demkowicz-Dobrzanski, M. Kacprowicz, W. Wasilewski, K. Banaszek, U. Dorner, B. J. Smith, J. S. Lundeen, I. A. Walmsley, *Quantum-enhanced phase estimation in the presence of loss*, Lasers and Electro-Optics 2009 and the European Quantum Electronics Conference. CLEO Europe - EQEC 2009. Contribution of the applicant: consultation, about 5%

C6. W. Wasilewski, M. G. Raymer, *Pairwise entanglement and readout of atomic-ensemble and optical wave-packet modes in traveling-wave Raman interactions*, Lasers and Electro-Optics, 2006 and 2006 Quantum Electronics and Laser Science Conference. CLEO/QELS (2006). Contribution of the applicant: calculations, analysis, about 50%

C7. A. Radunsky, E. Williams, I. Walmsley, P. Wasylczyk, W. Wasilewski and A. U'Ren, *Simplified spectral phase interferometry for direct electric-field reconstruction using a thick nonlinear crystal*, 2005 Conference on Lasers & Electro-Optics (CLEO), Vol. 3, 1820-1822, (2005). Contribution of the applicant: participation in measurements and data analysis, about 10%

C8. K. Banaszek and W. Wasilewski, *Linear-optics manipulations of photon-loss codes*, Proceedings of NATO Advanced Research Workshop "Quantum Communication and Security", quant-ph/0702091. Contribution of the applicant: calculations, about 30%

C9. Piotr Wasylczyk, Wojciech Wasilewski, Marek Trippenbach, and Czesław Radzewicz, *Observation of critical self focusing during propagation of femtosecond light pulses in bulk media,* Proc. SPIE 5949, 59491M (2005). Contribution of the applicant: calculations, participation in measurements, about 25%

C10. Andrzej Dragan, Wojciech Wasilewski, Konrad Banaszek, and Czesław Radzewicz, *Demonstrating Entanglement-Enhanced Communication over Noisy Communication*

Channels, AIP Conf. Proc. 734, 55 (2004). Contribution of the applicant: participation in experimental preparations and measurements, about 20%

C11. P. Wasylczyk, W. Wasilewski, M. Matuszewski, M. Trippenbach, C. Radzewicz, *Nonlinear propagation of femtosecond laser pulses in dielectrics,* Proc. SPIE Vol. 5258, 20 (2003). Contribution of the applicant: calculations, participation in measurements, about 25%

C12. C. Radzewicz, W. Wasilewski, P. Wasylczyk, M. Trippenbach, J. S. Krasinski, *Propagation of ultrashort laser pulses through transparent dielectrics in nonlinear regime*, Proc. SPIE Vol. 4992, 55 (2003). Contribution of the applicant: calculations, participation in measurements, about 25%

D. Collective works, catalogs, documentation of scientific investigations, expert opinions, works of art:
None

E. Total *impact factor* according to JCR list by the year of publishing: 160.6

F. Number of citations according to the Web of Science database: 1014
Excluding autocitations: 978

G. Hirsch index according to the Web of Science database: 15

H. Leading international and domestic research projects and participation in such

a. Leader of projects:

i. Diagnostyka homodynowa wielomodowych kwantowych stanów światła, N202 157 31/2958 (finished)

ii. IUWENTUS PLUS, 2011, „Wielomodowy generator stanów kwantowych na parach atomowych" (finished)

iii. SONATA, 2012-2016, „Generowanie, przetwarzanie i odtwarzanie wielu kolektywnych wzbudzeń w parach atomowych"

b. Investigator in projects:

i. Nieliniowa propagacja ultrakrótkich impulsów laserowych w dielektrykach 2P03B 029 26, leader: prof. C. Radzewicz (finished)

ii. Nowoczesne metody fizyki zimnej materii i inżynierii kwantowej w grupie Inżynieria stanów kwantowych - sterowanie kwantowe i generacja stanów splątanych fotonów i atomów PBZ/KBN/043/P03/2001 (finished)

iii. Parametryczne wzmacnianie femtosekundowych impulsów światła KBN 2PO3B01918, leader: prof. C. Radzewicz (finished)

iv. Zastosowanie technik kwantowej korekcji błędów w kryptografii kwantowej, 1 P03B 011 29, leader: dr hab. K. Banaszek (finished)

v. Zintegrowany projekt Europejski "Qubit Applications" , leader: dr hab. K. Banaszek (finished)

vi. Parametryczne wzmacnianie ultrakrótkich impulsów światła; rola konfiguracji niewspółosiowej N202 019 32/0698, leader: prof. C. Radzewicz (finished)

vii. Ultraprecyzyjne pomiary metodami optyki i fizyki atomowej, N N202 1489 33, projekt KL FAMO (finished)

viii. Projekt TEAM FNP pt. „Photonic Implementations of Quantum-Enhanced Technologies" kierownik: prof. K. Banaszek (finished)

I. International and domestic scientific awards

a. Ministry scholarship for outstanding young scientists (2013)
b. Scholarship of „modern university" programme (2009).
c. Prime Minister award for PhD thesis (2008)
d. Profesor Stefan Pieńkowski Award (2007)
e. Scholarship of Marshal of Kujawsko-Pomorskie for PhD students „Krok w przyszłość" 2006/07
f. Scholarship of Foundation for Polish Science for young scientists, 2006/07

J. Invited talks

a. Quantum Optics VII, 8-12 czerwiec 2009, Zakopane, „Robust source of ultra narrowband entanglement"
b. XII International Conference on Quantum Optics and Quantum Information, Wilno, 20-23 wrzesień 2008, "Experimental characterization of down conversion based photon sources"

6. Teaching, popularization and international cooperation

A. Participation in european programmes
Workpackage coordinator for purchase of scientific equipment in Phoqus@UW, REGPOT project

B. Active participation in international and domestic conferences
As in pt. 5J

C. Scientific supervision of students
Enginner theses: 4 person on Nicolaus Copernicus University in Toruń
Bachelor thses: 7 person on University of Warsaw
Master theses:
Mateusz Bawaj, UMK, 2010
Radosław Chrapkiewicz, UW, 2011
Michał Dąbrowski, UW, 2014
Daniel Pęcak, UW, 2014

D. Scientific supervision of PhD studens as advisor or auxiliary advisior
Auxiliary advisior for mgr Radosław Chrapkiewicz and mgr Michał Dąbrowski.

E. Stays inscientific institutions
2008-2009 Niels Bohr Institute Kopenhaga:
Postdoc in prof. E. Polzika group

F. Reviewes of manusripts for intenational and domestic periodicals
Starting from 2005 I wrote over 10 reviews for: Physical Review Letters, Physical Review A, Optics Letters, Optics Express, Optics Communications.

Wojciech Wasilewski