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ANNALES  
UNIVERSITATIS MARIAE CURIE-SKŁODOWSKA  
LUBLIN – POLONIA  
VOL. LXX SECTIO AAA 2015

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A REVIEW OF SOME SCIENTIFIC PAPERS BY  
PROF. STANISŁAW SZPIKOWSKI

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ABSTRACT

A short review of the most important (arbitrary choice) papers published by Prof. Stanisław Szpikowski (1926–2014) is presented.

Professor dr hab. Stanisław Szpikowski began his adventure with physics as the experimentalist. As the research-and-teaching vice-assistant in the Cathedral of Experimental Physics of the Maria Curie-Skłodowska University (UMCS) he started to work on thermodiffusion measuring the thermodiffusion coefficients for different elements and their isotopes (Kilka uwag dotyczących doświadczalnego wyznaczania stałej dyfuzji termicznej dla izotopów, *Annales UMCS, Sectio AA, vol. VIII (1953) 35–56*). Next he prepared some experiments which allow to observe some parameters and evolution of thermodiffusion in gases (Wyznaczanie stałych potencjału wodoru, dwutlenu węgla i mieszaniny  $H_2 - CO_2$ , *Annales UMCS, Sectio AA, vol. XIV (1959) 1–27*; Przebieg termodyfuzyjny mieszaniny  $H_2 - CO_2$  w zależności od czasu temperatury, ciśnienia oraz składu mieszaniny, *Annales UMCS, Sectio AA, vol. XIV (1959) 29–48*; Thermodiffusion process of gases in a horizontal tube, *Folia Soc. Scient. Lublinensis, Sectio C, 2 (1962) 116–119*; Thermodiffusion process of gases in a horizontal tube. Experimental part, *Folia Soc. Scient. Lublinensis, Sectio C, vol 5/6 (1965/66) 3–5*). On the other hand, it was the first time when Prof. Szpikowski started to think about theoretical physics. He considered the contemporary theory of thermodiffusion using the simplified thermodiffusion equation:

$$\frac{\Gamma_k}{n} = -D_{12} \nabla c_k + (-1)^{k+1} \frac{D_T}{T} \nabla T, \quad (1)$$

which contains the measurable thermodiffusion constant  $\alpha$ :

$$\frac{D_T}{D_{12}} = \alpha c_1 c_2. \quad (2)$$

The coefficients  $\Gamma_k$  ( $k = 1, 2$ ) are the streams of lighter and heavier isotope,  $n$  denotes the gas density (mixture of isotopes),  $c_k = n_k/n$  is the concentration of light ( $k = 1$ ) and heavy ( $k = 2$ ) isotope in the normal gas.  $D_{12}, D_T$  are the diffusion and thermodiffusion coefficients, respectively.

The thermodiffusion constant  $\alpha$  was calculated by Nier a few decades earlier (A.O. Nier, Phys. Rev. 56 (1939) 1009). He obtained this coefficient for the  $n$ -step process as the following expression:

$$\alpha = \frac{{}^n c_2^0 - c_2 \frac{T_1}{T_0} + 1}{c_1 c_2 \frac{n \log \frac{T_1}{T_0}}{n}}. \quad (3)$$

After some analysis this thermodiffusion constant for  $n$ -step process was improved by Szpikowski who included in calculation the processes of higher order:

$$\alpha = \frac{\frac{T_1}{T_0} + 1}{\log \frac{T_1}{T_0}} \left\{ \frac{{}^n c_2^0 - c_2}{n c_1 c_2} + \frac{(n-1)(c_1 - c_2) {}^n c_2^0 - c_2}{2n^2 n c_1 c_2} \right\}. \quad (4)$$

where  $c_1^l, c_2^l$  are the concentration of light and heavy isotope in the cold ( $l = 0$ ) and hot ( $l = 1$ ) containers.  $T_0, T_1$  denote temperatures of the cold and hot container.

These investigations allowed him to defend the Ph.D. thesis at the Maria Curie-Skłodowska University, Lublin, in 1960. The supervisor of his Ph.D. was Prof. Armin Teske.

After obtaining Ph.D. he turned the subject of his research to theoretical physics, or more precisely to the theoretical nuclear physics. This decision coincided with his visit at the University of Manchester, England, where he joined the group of B.H. Flowers (1979, Lord Flowers of Queen's Gate). This was a beginning of theoretical physics researches at the MCS University in Lublin.

The first studies in theoretical physics were devoted to the nuclear shell model calculations. These calculations were done for energy levels in the nucleus  $K^{40}$  (*Shell Model Calculations of the Energy Levels in  $K^{40}$* , Acta Phys. Polonica, 25 (1964) 169–177). At this time, the nuclear shell model calculations were the hottest topic in nuclear physics. Still, until today shell model is one of the most important models of nuclear physics.

During work at the University of Manchester Prof. Szpikowski found also a good atmosphere to learn quite new and very effective method based on the Lie groups theory. Collaboration with B.H. Flowers resulted in a new group theoretical classification scheme of nuclear shells. In fact, about ten years earlier Flowers invented the classification scheme for the single  $j$ -shell (Proc. Roy. Soc. A 210 (1951) 197; Proc. Roy. Soc. A 212 (1952) 248), however, the generators of the corresponding group conserved the number of particles: they were generated by infinitesimal operators constructed from the fermionic creation/annihilation

operators  $a_{mm}$ , where  $m = \pm 1/2$  is the projection of the total angular momentum and  $m_t = \pm 1/2$  is the projection of the isospin of a nucleon, respectively:

$$(a^+a)^{JT} \begin{cases} \nearrow (a^+a)^{(J,0)} \rightarrow (a^+a)^{(J_{tot},0)} \rightarrow (a^+a)^{(1,0)} \\ \searrow (a^+a)^{(0,1)} \end{cases} \quad (5)$$

Conservation of the particles number by the generators does not allow to incorporate the pairing interaction in the nuclear Hamiltonian which seems to be the most important part of the nuclear residual interaction. The resulting states can be labelled as:

$$|j^n; (nT) \alpha_1(st) \alpha_2(J, J_0)\rangle. \quad (6)$$

To include nuclear pairing interaction into the classification scheme the authors: Flowers and Szpikowski (*A generalized quasi-spin formalism*, Proc. Phys. Soc. 84 (1964) 193–199; *Quasi-spin in LS coupling*, Proc. Phys. Soc. 84 (1964) 673–679) generalized the idea of the quasi-spin method invented by Anderson, Wada, Takano and Fokuda who constructed the quasi-spin operators for only one kind of particles sitting on the single  $j$ -shell:

$$Q_+ = \frac{\sqrt{2j+1}}{2} (a_j^+ a_j^+)^{j-0}, \quad Q_- = (Q_+)^{\dagger}, \quad Q_0 = \frac{1}{2} \left( \hat{n} - j - \frac{1}{2} \right) \quad (7)$$

One of the most important features of this formalism was a possibility of analytical solutions for energies and eigenfunctions of the corresponding Hamiltonian. In this case, the generalized pairing Hamiltonian in  $j^n$  configuration can be written as:

$$H_p - H_p(Q_+Q_-, Q_0) \quad (8)$$

and the analytical form for the eigenenergies is:

$$E_p = H_p \left( -\frac{1}{4}(n-v)(2j+3-n-v), \frac{1}{2} \left( n - j - \frac{1}{2} \right) \right). \quad (9)$$

Szpikowski and Flowers extended the quasi-spin idea for the case of nucleons (two kinds of particles). They identified the resulting group as the orthogonal group in five dimensions  $SO(5)$ . The generators of this group include the pairing operators for nucleons:

$$\begin{aligned} S_+^k &= \sum_{m>0} ((-1)^{j-m} a_{jmk}^+ a_{j-mk}^+), \quad k = p, n, \\ S_+^{np} &= \sum_{m>0} ((-1)^{j-m} (a_{jmp}^- a_{j-mn}^+ + a_{jmn}^+ a_{j-mp}^+)), \\ S_+^q &= (S_+^q)^{\dagger}, \quad q = n, p, np, \\ T_1 &= \sum_{m>0} (a_{jmn}^+ a_{jmp}^+ + a_{j-mp}^+ a_{j-mn}^+) = (T_1)^{\dagger}, \\ T_0 &= \frac{1}{2} \sum_{m>0} (a_{jmn}^+ a_{jmn}^+ + a_{j-mn}^+ a_{j-mn}^+ - a_{jmp}^+ a_{jmp}^+ - a_{j-mp}^+ a_{j-mp}^+), \\ S_0^{np} &= \frac{1}{2} \sum_{m>0} (a_{jmn}^+ a_{jmn}^+ + a_{j-mn}^- a_{j-mn}^+ + a_{jmp}^+ a_{jmp}^+ + a_{j-mp}^- a_{j-mp}^+ - 2). \end{aligned}$$

The corresponding pairing Hamiltonian and the eigensolutions can be written as:

$$\begin{aligned} \langle H_P \rangle &= -G \langle \sum_{k=n,p} S_+^k S_-^k + \frac{1}{2} S_+^{np} S_-^{np} \rangle \\ &= -\frac{1}{4} G \{ (n-v)(2j+4 - \frac{1}{2}n - \frac{1}{2}v) - 2T(T+1) + 2t(t+1) \}. \end{aligned} \quad (10)$$

This is an important result which allows to understand more deeply the nature of pairing interaction among nucleons.

One of the unsolved problems for the  $SO(5)$  quasi-spin is lack of one physical quantum number required for full classification of states. Prof. Szpikowski tried to solve this problem introducing the additional commuting operator which allows to make the classification of states in respect to the chain

$$SO(5) \supset SO(3) \quad (11)$$

unique. The additional observable was constructed as the four-body operator being the product of the operators which annihilate and create two pairs of nucleons, each pair with  $J = 0, T = 1$ :

$$\beta_- = \frac{1}{4} (S_-^{np})^2 - S_-^n S_-^p, \quad \beta_+ = \beta_-^\dagger, \quad \beta = \beta_+ \beta_- . \quad (12)$$

In this case, the complete set of commuting operators is given by:

$$\beta, S_0^{np}, T^2, T_0. \quad (13)$$

However, this solution, though correct, gives rather complicated construction of required states and representations. In this sense it is unsatisfactory.

Independently of this problem, there is a question: why the quasi-spin classification is better than the standard spectroscopy based on the unitary group (Racach, Flowers):

$$U(2j+1) \supset Sp(2j+1) \supset SO_j(3). \quad (14)$$

In the old standard case the highest symmetry is characterized by “trivial” quantum numbers  $n, T$ . In addition, the highest group is unnecessarily complicated and different starting groups are required for different  $j$ .

In case of the quasi-spin spectroscopy (Flowers, Szpikowski):

$$SO(5) \times Sp(2j+1) \supset [SU_T(2) \times U_N(1)] \times SO_j(3) \quad (15)$$

the highest symmetry is represented by a simple group. The physical quantum numbers  $n, T$  are related to some subgroups. They allow to use the Wigner-Eckart theorem. The same starting quasi-spin group is required for different  $j$  and, in addition, both  $SO(5)$  and  $Sp(2j+1)$  are labelled by the seniority  $v$  and the reduced isospin  $t$ .

The second important contribution of Prof. Szpikowski into nuclear spectroscopy is the other chain of quasi-spin operators related, not as previous one to  $j$ - $j$  scheme, but to  $l$ - $s$  coupling.

In this case, Szpikowski and Flowers also found the appropriate quasi-spin group. It is isomorphic the  $SO(8)$  and it is generated by the following combinations of creation and annihilation operators:

- Single  $l + s + t$  level

$$\left\{ \begin{array}{l} (a^\dagger a^\dagger)^{(LST)} \\ (aa)^{(LST)} \\ (a^+ a)^{(LST)} \end{array} \right\} \begin{array}{l} \nearrow \\ \searrow \end{array} \begin{array}{l} (a^+ a)^{(L,0,0)} \rightarrow (a^+ a)^{(1,0,0)} \\ \left\{ \begin{array}{l} (a^+ a^+)^{(0ST)} \\ (aa)^{(0ST)} \\ (a^\dagger a)^{(0ST)} \end{array} \right\} \rightarrow (a^- a)^{(0ST)} \begin{array}{l} \nearrow \\ \searrow \end{array} \begin{array}{l} (a^+ a)^{(010)} \\ (a^+ a)^{(001)} \end{array} \end{array}$$

In this case one gets the important isoscalar pairing  $T = 0$ .

Both quasi-spin classifications seems to be important contribution of Prof. Szpikowski to nuclear physics. They determined also his scientific research program for next several years. As a result is the set of some publications. The most important papers from this series are:

- *The Search for the Common Symmetry of Pairing + Quadrupole Forces in Nuclear Theory* (coauthor: K. Pomorski), Acta Physica Polonica, B1 (1970) 3–12
- *On the New Quasi-Particle Factorization of the  $j$ -shell* (coauthor: K.T. Hecht), Nuclear Physics A158 (1970) 449–475
- *Factorization of the  $j = 7/2$  shell of Neutron and Protons. Transformation coefficients to States of Good Particle Number* (coauthors: W.A. Kamiński K.T. Hecht), Atomic Data na Nuclear Data Tables, 16 (1975) 311–381
- *Alpha-Clusters in Nuclei with  $41 \leq A \leq 45$*  (coauthor: M. Trajdos), Nuclear Physics A272 (1976) 155–173
- *An IBM Analysis of a single  $j$ -shell of neutrons and protons* (coauthors: J.P. Elliott i T. Evans), Nucl. Phys. A435 (1985) 317–332

About the 80's a new idea of treating nuclei as the system of bosons became the new scientific challenge of Prof. Szpikowski. The Interacting Boson Model allowed to use similar algebraic methods as in the quasi-spin problem and related works. In the simplest case, the successful  $s, d$  model consist of the monopole and quadrupole bosons:  $s^2, d_\mu^+$  generated the group  $SU(6)$ :

$$s^+ s, (d^+ \tilde{d})^L_M, s^+ \tilde{d}_\mu, d_\mu^+ s \text{ where } L = 0, 1, 2, 3, 4. \tag{16}$$

An important property of this group is that it allows for a few group chains which are able to describe some vibrational, rotational and transitional nuclei. For example, the vibrational chain contains as the subgroups the same groups as those required by the five dimensional harmonic oscillator (Bohr Hamiltonian), so successful in description of nuclear quadrupole motion:

$$U(6) \supset U(5) \supset O(5) \supset O(3). \quad (17)$$

At that time, the basis for the Bohr Hamiltonian was unknown, because it was a difficult task to construct the basis including required physical groups. However, it turned out that by analogy to the quasi-spin approach, there exists an alternative solution based on another group chain:

$$SU(1, 1) \times O(5) \supset U(1) \times O(3). \quad (18)$$

This idea allowed to construct the basis for the vibrational case of the Interacting Boson Model (IBM) and, at the same time for the Bohr Hamiltonian:  $|vNn_{\Delta}LM\rangle$ , where  $v$  is the boson seniority number,  $N$  denotes the total number of bosons,  $\Delta$  can be interpreted as the maximal number of boson triplets coupled to the angular momentum  $L=0$ , and as usually  $L, M$  describe the angular momentum of the system. The most important papers concerning the IBM models are listed below:

- *The orthonormal basis for symmetric Irreducible Representations of  $O(5) \times SU(1,1)$  and its application to Interacting Boson Model* (coauthor: A. GóŹdź) Nucl. Phys. A340 (1980) 76-92
- *Complete and orthonormal solution of the five-dimension spherical harmonic oscillator in Bohr-Mottelson collective coordinates* (coauthor: A. GóŹdź) Nucl. Phys. A349 (1980) 359–364
- *Interacting Boson Model and  $3^-$  nuclear states in even–even nuclei* (coauthor: K. Zając) [in] Symmetries in Science VII, Plenum Publishing Corporation, N.Y. 1994, 545–555

Supersymmetry is a general concept which is mostly applied on the fundamental level, e.g. in field theory. Because of successes of both fermionic and bosonic nuclear models the idea of using supersymmetric algebra seemed to be a natural consequence. Prof. Szpikowski was interested in a possibility of existence of nuclear supersymmetry. However, after some work and a series of papers

- *Search for Supersymmetry in Light Nuclei* (coauthors: P. Kłosowski and L. Próchniak) Nucl. Phys. A487 (1988) 301–318
- *Supersymmetry scheme for nuclei  $32 \leq A < 40$*  (coauthor: L. Próchniak) Acta Phys. Polonica B24 (1993) 557–571
- *Binding energy of the  $sd$ -shell nuclei in the supersymmetric model* (coauthors: L. Próchniak and W. Berej) J. Phys. **G23** (1997) 705–715

it turned out that it is very difficult to show the existence of supersymmetry in real nuclei. Independently of this, the idea of nuclear supersymmetry is still an open and interesting problem, maybe on more fundamental level, like the field theoretical/quark model of nuclei.

Prof. Szpikowski was always interested in principles of quantum mechanics. The first, second and third edition of his textbook on quantum mechanics (S. Szpikowski, *Podstawy mechaniki kwantowej*, Wydawnictwo UMCS, 1999, 2006, 2011) are good introduction to problems of quantum physics. This textbook was systematically updated. This subject was a kind of hobby of Prof. Szpikowski, not only on the level of physics but also as a philosophical problem. For example, the problem of time in quantum mechanics (*Czas w mechanice kwantowej (Time in*

*Quantum Mechanics*), Roczniki Filozoficzne 25 (1977) 11–24) where he tried to analyse the following questions:

- If the current of time – also biological – is different in various frames of references, does it seem to be supported by quantum mechanics?
- If the micro-objects exist between measurement points and if they exist how do they behave?

It is a pity, however, these problems are very fundamental and they do not have accepted solutions till now.

Prof. S. Szpikowski published 85 research articles, 19 conference papers, 7 review articles, 7 books and scripts. He also wrote 5 popular articles about physics and more than 50 publications (a part of them is now nearly unavailable) on different subjects.

Below, there are listed practically all papers published by Prof. S. Szpikowski and his collaborators.

## LIST OF PAPERS

### I. SCIENTIFIC PAPERS

1. Szpikowski S., 1953. Kilka uwag dotyczących doświadczalnego wyznaczania stałej dyfuzji termicznej dla izotopów, *Annales UMCS, Sectio AA*, Vol. VIII, 35–56.
2. Szpikowski S., 1959. Wyznaczanie stałych potencjału wodoru, dwutlenku węgla i mieszaniny  $H_2 - CO_2$ , *Annales UMCS, Sectio AA*, Vol. XIV, 1–27.
3. Szpikowski S., 1959. Przebieg termodyfuzyjny mieszaniny  $H_2 - CO_2$  w zależności od czasu temperatury, ciśnienia oraz składu mieszaniny, *Annales UMCS, Sectio AA*, Vol. XIV, 29–48.
4. Szpikowski S., 1962. Thermodiffusion process of gases in a horizontal tube, *Folia Soc. Scient. Lublinensis, Sectio C*, 2, 116–119.
5. Szpikowski S., 1964. Shell Model Calculations of the Energy Levels in  $K^{40}$ , *Acta Phys. Polonica*, Vol. XXV, 169–177.
6. Flowers B.H., Szpikowski S., 1964. A generalized quasi-spin formalism, *Proc. Phys. Soc.* Vol. 84, 193–199.
7. Flowers B.H., Szpikowski S., 1964. Quasi-spin in LS coupling, *Proc. Phys. Soc.* Vol. 84, 673–679.
8. Flowers B.H., Szpikowski S., 1965. A four-body operator in nuclear spectroscopy, *Proc. Phys. Soc.* Vol. 86, 672–674.
9. Sielanko J., Szpikowski S., 1965/66. Thermodiffusion process of gases in a horizontal tube. Experimental part, *Folia Soc. Scient. Lublinensis, Sectio C*, vol 5/6, 3–5.
10. Szpikowski S., 1964. Pairing approximation for  $d_{3/2}$  and  $f_{7/2}$  nuclear shells, *Annales UMCS, Sectio AA*, Vol. XIX, 77–87.
11. Szpikowski S., 1966. Quasi-spin representations of the orthogonal group  $R_6$ , *Acta Physica Polonica*, Vol. XXIX, 853–874.

12. Szpikowski S., Mazur-Goebel A., 1966. Matrix elements of the pairing hamiltonian for the  $D(\lambda, 0)$  representation of the  $R_{\mathfrak{G}}$  group in the  $(nTT_0)$  basis, Annales UMCS, Sectio AA, Vol. XXI, 85–92.
13. Szpikowski S., 1967. The combinatorial method in matrix elements of  $J_+$  operators, Acta Physica Polonica, Vol. XXXI, 597–598.
14. Szpikowski S., 1967. Quasi-Spin Method in Nuclear Spectroscopy, Zeszyty Naukowe Uniwersytetu Jagiellońskiego, Vol. CLXXVII, 139–147.
15. Sielanko J., Szpikowski S., Kowalczevska-Rosińska Z., 1967/1968. Convection effect in thermodiffusion process, Folia Soc. Scient. Lublinensis, Sectio C, Vol. 7/8, 19–21.
16. Szpikowski S., Trajdos M., 1969/1970. Exact diagonalization of pairing interactions for protons and neutrons in  $j - j$  coupling. I. Even nuclei,  $d_{3/2} - f_{7/2}$  shells, Annales UMCS, Sectio AA, Vol. XXIV/XXV, 13–25.
17. Szpikowski S., Wójcik A., 1969/1970. Exact diagonalization of pairing interactions for protons and neutrons in  $j - j$  coupling. II. Odd nuclei,  $d_{3/2} - f_{7/2}$  shells, Annales UMCS, Sectio AA, vol. XXIV/XXV, 27–35.
18. Rozmej P., Szpikowski S., 1969/1970. Mutual dependence of pairing interactions in  $L - S$  and  $j - j$  coupling, Folia Soc. Scient. Lublinensis, Sectio C, Vol. 9/10, Suppl., 135–148.
19. Pomorski K., Szpikowski S., 1970. The Search for the Common Symmetry of Pairing + Quadrupole Forces in Nuclear Theory, Acta Physica Polonica, Vol. B1, 3–12.
20. Hecht K.T., Szpikowski S., 1970. On the New Quasi-Particle Factorization of the  $j$ -shell, Nuclear Physics, Vol. A158, 449–475.
21. Szpikowski S., Trajdos M., 1974. Four-Body Model-Interactions in Nuclei, Nukleonika, Vol. 19, 727–732.
22. Szpikowski S., Kamiński W., 1974. Complete Factorization of the  $j = 7/2$  Nuclear Shell, Folia Soc. Scient. Lublinensis, Sectio C, Vol. 16, 31–35.
23. Baran A., Szpikowski S., 1974. Exact Diagonalization of the Pairing and Quadrupole Hamiltonian for Some Simple Cases, Folia Soc. Scient. Lublinensis, Sectio C, Vol. 16, 37–42.
24. Król S., Szpikowski S., 1975. Beta-Decay, Magnetic Moments and the  $0(5)$  Group, Acta Physica Polonica, Vol. B6, 409–419.
25. Kamiński W., Szpikowski S., Hecht K.T., 1975. Factorization of the  $j = 7/2$  Shell of Neutron and Protons. Transformation Coefficients to States of Good Particle Number, Atomic Data and Nuclear Data Tables, 16, 311–381.
26. Szpikowski S., 1975. Isoscalar and Isovector Competition in Pairing Forces, Folia Soc. Scient. Lublinensis, Sectio C, vol. 17, 171–175.
27. Szpikowski S., Kamiński W.A., 1976. Połnaja faktorizacja oboloczki  $j = 7/2$ , Izwiestia Ak. Nauk ZSRR, 40, 138–140.
28. Szpikowski S., Trajdos M., 1976. Alpha-Clusters in Nuclei with  $41 \leq A \leq 45$ , Nuclear Physics, A272, 155–173.
29. Szpikowski S., 1976/1977. 30 lat ośrodka fizyki w Uniwersytecie Marii Curie-Skłodowskiej w Lublinie (1944–1974), Annales UMCS Lublin, Sectio AAA, Vol. XXXI/XXXII, 17–40
30. Szpikowski S., 1977. Czas w mechanice kwantowej, Roczniki Filozoficzne, Tom XXV, 11–24



31. Szpikowski S., Kamiński W.A., 1978. Primienienije nowoj kwaziczasticznoj faktorizacjonnoj schemy k jadram  $1f_{7/2}$  obołoczki, Izwestia Akademii Nauk ZSRR 42, 807–812.
32. Szpikowski S., Zajac K., 1978. Matrix elements of iso–scalar  $T = 0$  pairing forces and coefficients of fractional parentage, Folia Soc. Scient. Lubltnensis, Sectio C, vol. 20, 37–45.
33. Gózdź A., Szpikowski S., 1978. The Complete Base of the Symmetric Representation of the  $O(5) \times SU(1,1)$  Group Folia Soc. Scient. Lublinensis, Sectio C, vol. 20 () 151–154.
34. Kamiński W.A., Szpikowski S., 1979. Recepcja mechaniki kwantowej w polskich ośrodkach naukowych w latach dwudziestych Studia i Materiały z Dziejów Nauki Polskiej, Seria C, 105–109.
35. Gózdź A., Szpikowski S., 1978. Interacting Octupole Bosons and its Group Theory Background Annales UMCS, Sectio AAA, vol. XXXIII, 1–10.
36. Szpikowski S., Gózdź A., 1980. The orthonormal basis for symmetric Irreducible Representations of  $O(5) \times SU(1,1)$  and its application to Interacting Boson Model, Nucl. Phys. A340, 76-92.
37. Szpikowski S., 1980. Prostaja simetria dla obołoczki garmoniczeskowo oscilatora w sluczajach parnego, kwadrupolnogo i kwadrupol–parnogo wzaimodiejstwa Izwestia Akademii Nauk ZSRR 44, 1010–1012.
38. Kamiński W., Szpikowski S., 1980. Wycislenie kulombowskiej energii dla jadier obołoczki  $1f_{7/2}$  Izwestia Akademii Nauk ZSRR 44, 1013–1018.
39. Gózdź A., Szpikowski S., 1980. Complete and orthonormal solution of the five-dimension spherical harmonic oscillator in Bohr-Mottelson collective coordinates Nucl. Phys. A349, 359–364.
40. Gózdź A., Szpikowski S., Zajac K., 1980.  $SU(13) \supset U(1) \times SU(5) \times SU(7)$  chain in IBM, Nukleonika, Vol. 25, 1055–1065.
41. Szpikowski S., Gózdź A., 1980. Primienienie symetriczeskogo bazisa k połnomu i ortogonalnomu reszeniu sobstwienej problemy sfericzeskowo kolektiwnowo gamiltoniana Bohra, Izwestia Akademii Nauk Kazachskoj SSR, 6, 46–51.
42. Szpikowski S., 1980. Idee relatywistyczne w mechanice kwantowej Roczniki Filozoficzne, Tom XXVIII, 15–25.
43. Szpikowski S., 1980. The common symmetry of the pairing, quadrupol and quadrupol–paring interactions for the harmonic oscillator shell, Folia Soc. Scient. Lublinensis, Sectio C, Vol. 22, 97–100.
44. Szpikowski S., 1983. Mikroskopowa interpretacja bozonów „s” w formalizmie izospinu, Annales UMCS Lublin, Sectio AAA, vol. XXXVIII, 167–178
45. Szpikowski S., Trajdos M., 1984. Four-particle correlations in nuclei on the  $sd - f_{7/2}$  levels, Acta Phys. Polonica, Vol. B15, 673–687.
46. Szpikowski S., 1984. Toward better understanding of Nuclear Collective Models, Proceed. Symp. „Nuclear Collective States”, Łódź (Poland), ed. Łódź University, 102–122.
47. Evans J.A., Elliott J.P., Szpikowski S., 1985. An IBM Analysis of a single  $j$ -shell of neutrons and protons, Nucl. Phys. A435, 317–332.
48. Szpikowski S., Zajac K., 1985. One the interpretation of monopole IBM bosons in terms of the collective pairing field, XX Winter School, Vol. 1, Zakopane (Poland), April, Proceedings, 417–430.

49. Berej W., Gózdź A., Szpikowski S., 1984. The Complete Physical Basis for the Irreducible Representations of the Group  $SO(5)$ , *Folia Soc. Scient. Lublinensis*, Vol. 26, 25–29.
50. Zając K., Szpikowski S., 1986. The new diagonalization procedure in the Interacting Boson Model and its application, *Acta Phys. Polonica*, Vol. B17, 1109–1119.
51. Szpikowski S., 1985. Symmetry of nucleon pairs and the Interacting Boson Model, Summer School on Nuclear Physics, Mikołajki (Poland), Proceedings, 193–200.
52. Szpikowski S., 1986. Four-body microscopical interpretation of the Interacting Boson Model, I-st International Spring Seminar on Nuclear Physics, Sorrento, p. 275–283.
53. Szpikowski S., Kłosowski P., Próchniak L., 1986. Fermion–Boson Model with Isospin Formalism, Int. Nuclear Conference, Dubrovnik, Proceedings, 265–271.
54. Szpikowski S., Kłosowski P., Próchniak L., 1987. Supersymmetry in Light Nuclei, Summer School of Nuclear Physics, Mikołajki (Poland), Proceedings.
55. Szpikowski S., Kłosowski P., Próchniak L., 1988. Search for Supersymmetry in Light Nuclei, *Nucl. Phys. A*487, 301–318.
56. Szpikowski S., Zając K., Król D., 1988. Nucleon Pairs and the Interacting Boson Model in Negative Parity States, Summer School in Nuclear Physics, Mikołajki (Poland), Proceedings, 84–93.
57. Szpikowski S., Zając K., Król D., 1988. Negative parity states and the Interacting Boson Model, 2-nd International Spring Seminar on Nuclear Physics, Capri, Proceedings, 513–522.
58. Szpikowski S., Trajdos M., Tambor R., 1988/1989. Four-Particle Correlations in the Even Ca and Ti Isotopes, *Annales UMCS Lublin, Sectio AAA*, vol. XLIII/XLIV, 303–313.
59. Szpikowski S., Berej W., 1990. A new physical basis for the irreducible representations of the orthogonal group  $SO(5)$  in the quasi-spin formalism, *Jour. Phys. Vol. A*23, 3409–3420.
60. Szpikowski S., Kłosowski P., Próchniak L., 1990. Supersymmetry and Electromagnetic  $E2$  Transitions, *Z. Phys. Vol. A*335, 289–292.
61. Próchniak L., Szpikowski S., 1990. Boson expansion method of the Dyson–Maleev type for the fermion algebra  $Sp(6)$ , *Bull. Soc. Sci. Lettr. Łódź, ser. Recherches sur les déformations*, Vol. XL, No. 82, 15–22.
62. Szpikowski S., 1991. The elementary method in pairing energy. I. The like particles, *Acta Phys. Polonica* Vol. 22, 641–652.
63. Szpikowski S., 1991. The elementary method in pairing energy. II. Protons and neutrons in an isospin formalism, *Z. Phys. Vol. A*339, 37–41.
64. Próchniak L., Szpikowski S., 1993. Supersymmetry scheme for nuclei  $32 \leq A < 40$ , *Acta Phys. Polonica* Vol. B24, 557–571.
65. Szpikowski S., Zając K., 1994. Interacting Boson Model and  $3^-$  nuclear states in even–even nuclei, [in] *Symmetries in Science VII*, Plenum Publishing Corporation, N.Y., p. 545–555.
66. Szpikowski S., 1994. Ośrodek fizyki UMCS w latach 1944–1976, *Annales UMCS, Sectio AAA*, Vol. XLIX, 27–43.
67. Szpikowski S., 1994. Ośrodek fizyki teoretycznej w latach 1977–1994, *Annales UMCS, Sectio AAA*, vol. 49, 65–71.
68. Szpikowski S., 1994. Katedra (Zakład) Fizyki Teoretycznej w okresie 50 lat UMCS, *Annales UMCS, Sectio AAA*, vol. 49, 128–141.

69. Szpikowski S., Ling Y.S., Próchniak L., 1995. The supersymmetry considerations in the first half of the sd shell, *Acta Phys. Pol. Vol. 26*, 1403–1411.
70. Szpikowski S., 1995. Confrontation of supersymmetry in elementary particles and nuclear physics, in: *Symmetries in Science VIII*, Plenum Press, New York and London, p. 553–561.
71. Szpikowski S., Próchniak L., Ling Y.S., 1996. Problems in supersymmetry of light nuclei, *Proceedings of the Spring Seminar Ravello 1995*, p. 1–10 (invited lecture), World Scientific, p. 243–251.
72. Szpikowski S., Próchniak L., 1995. Supersymmetry in elementary particles and nuclear physics, *Proceedings of the Dubna Conference*, p. 1–10.
73. Szpikowski S., Próchniak L., Berej W., 1996. Application of the supersymmetric model to Exotic nuclei in: *Symmetries in Science IX (Bregenz)*, Plenum Press 1977.
74. Próchniak L., Szpikowski S., Berej W., 1997. Binding energy of the *sd*-shell nuclei in the supersymmetric model, *J. Phys. Vol. G23*, 705–715.
75. Szpikowski S., Berej W., Próchniak L., 1997. Pairing and deformed pairing interaction for system of protons and neutrons, in: *Symmetries of Science X (Bregenz)*, Plenum Press 1998.
76. Szpikowski S., Próchniak L., Berej W., 1998. Supersymmetry and exotic nuclei, *Acta Phys. Polon. Vol. B29*, 301–311.
77. Szpikowski S., Próchniak L., Berej W., 1997. Supersymmetry mass formula in nuclear physics, *Proceedings of the Thessaloniki Conference*, July.
78. Szpikowski S., Elementary method in neutron-proton pairing correlations, Preprint ECT 97-008, p. 1–15.
79. Szpikowski S., 2000. Neutron–proton pairing correlations, *Acta Phys. Polon. Vol B31*, 443–448.
80. Szpikowski S., 2000. The elementary method in pairing energy. III. Neutron-proton versus like-nucleon correlations, *Acta Phys. Polon. Vol. B31*, 1823–1838.
81. Szpikowski S., 2002. Competition of neutron-neutron (proton-proton) and neutron-proton pairing correlations, *Proceedings of the 7th International Spring Seminars, Maiori, Italy, 27-31 May 2001*, p. 301–310, (World Scientific Publishing).
82. Szpikowski S., 2002. Systematic review of the generalized Bell inequalities, *Annales UMCS, Sectio AAA, Vol. LVII*, 89–106.
83. Szpikowski S., Próchniak L., 2003. Binding energy for nuclear supermultiplets in light nuclei, *Acta Phys. Polon. Vol. B34*, 2295–2299 item.
84. Szpikowski S., 2003. Przestrzeń mikroświata. In: “Przestrzeń we współczesnej nauce”, Zamość, p. 135–138.
85. Szpikowski S., 2007. 40 years of the dynamical proton-neutron pairing symmetry, *Int. Jour. of Mod. Phys. Vol. E16*, 199–209.

## II. CONFERENCE PROCEEDINGS

1. *Przebieg termodyfuzji izotopów gazowych*, XV Zjazd PTF 1957 r. (Materiały Zjazdowe, strona 15), Wrocław.
2. *Wyznaczanie stałych siłowych na podstawie danych lepkości i termodyfuzji*, XVI Zjazd PTF 1959 r. (Materiały Zjazdowe, strona 16), Toruń.
3. *Oddziaływanie dziura–cząstka w przypadku jądra  $K^{-40}$* , XVIII Zjazd PTF 1963 r. Materiały Zjazdowe, Katowice.

4. *Termodyfuzja gazów w poziomej rurze*, (wspólnie z: J. Sielanko) XVIII Zjazd PTF 1963 r. Materiały Zjazdowe, Katowice.
5. *Quasi-spinowe reprezentacje ortogonalnej grupy w pięciowymiarowej przestrzeni fazowej*, XIX Zjazd PTF 1965 r. (Materiały Zjazdowe, strona 2), Kraków.
6. *Elementy macierzowe hamiltonianu pairing dla reprezentacji grupy  $R_n$  w bazie  $(nTT_0)$* , (wspólnie z: A. Goebel) XIX Zjazd PTF 1967 r. (Materiały Zjazdowe, strona 74), Lublin.
7. *Quasi-spin in the new quasiparticle factorization of the  $j^n$  configuration*, (wspólnie z: K.T. Hecht) Bull. Amer. Phys. Soc., 15 April 1970, Paper GG, strona 13.
8. *Model Description of  $\alpha$ -Clusters in Nuclei*, (wspólnie z: M. Trajdos), Supplement Materiałów Międzynarodowej Konferencji (1976) 11–13.
9. *Przybliżenie oddziałujących bozonów kwadrupolowo-oktupolowych w teorii jądra atomu*, (wspólnie z: A. Gózdź i K. Zajac), XXVI Zjazd PTF 1979 r. (Materiały Zjazdowe, str. 12–13), Toruń.
10. *Bozonnyje symetrii kolektywnych dżwizenii*, (wspólnie z: A. Gózdź i K. Zajac), Tezisy Dokładów XXX Konf. Jądrowej ZSRR - Leningrad 1980, str. 201.
11. *Konstrukcja zupełnej fizycznej bazy grupy  $SO(5)$* , (wspólnie z: A. Berej i A. Gózdź), XXVII Zjazd PTF 1981 r. (Materiały Zjazdowe, strona 154), Lublin.
12. *Interpretacja modelu oddziałujących bozonów poprzez mikroskopowe oddziaływanie pairing + kwadrupol-pairing*, (wspólnie z: L. Próchniak i K. Zajac), XXVII Zjazd PTF 1981 r. (Materiały Zjazdowe, strona 162), Lublin.
13. *Czterociałowe korelacje nukleonów*, (wspólnie z: M. Trajdos), XXVII Zjazd PTF 1981 r. (Materiały Zjazdowe, strona 164), Lublin.
14. *Czterociałowa interpretacja oddziaływania bozonowego w teorii IBM (Interacting Boson Model)*, XXVIII Zjazd PTF 1984 r. (Materiały Zjazdowe, strona 240), Gdańsk.
15. *Four-Body Microscopic Interpretation of the Interacting Boson Model*, in: „Microscopic Approaches to Nuclear Structure Calculations”, Abstracts of the Sorrento Conference (1986).
16. *Fermion-Boson Model with Isospin Formalism*, (wspólnie z: P. Kłosowski i L. Próchniak), in: „Nuclear Structure, Reaction and Symmetries”, Abstracts of the Dubrovnik Conference (1986).
17. *Supersymmetry in Light Nuclei*, (wspólnie z: P. Kłosowski i L. Próchniak), Proceed. of the Intern. Conference on Nuclear Structure, Melbourne, Australia 1987, Contr. Paper (Abstract), p. 107.
18.  *$B(E2)$  Probability in a Supersymmetry Scheme*, (wspólnie z: P. Kłosowski, L. Próchniak), International Conference on Selected Problems in Nuclear Structure, Dubna (USSR) 1989, Conf. Papers (Abstract), p. 25.
19. *Supersymmetry mass formula in nuclear physics* (wspólnie z: L. Próchniak i W. Berej).
20. *European Conference on Advances in nuclear physics, Thessaloniki (Grecja) 1977 – Conf. Papers (Abstract) p. 149.*

### III. REVIEW ARTICLES

1. S. Szpikowski, *O dyfuzji termicznej izotopów gazowych*, Wiadomości Chemiczne, 9 (1955) 305–340.

2. S. Szpikowski, *A new approach to the old classification problem of nuclear states*, Proceed. of the Rossendorf Conference on nuclear structure (1966) 9–19.
3. S. Szpikowski, *Zastosowanie teorii grup w spektroskopii jądrowej*, Postępy Fizyki, Vol. 23 (1972) 541–560.
4. S. Szpikowski, *Nowe propozycje klasyfikacji stanów modelu powłokowego jądra atomu*, Postępy Fizyki, Vol. 23 (1972) 613–621.
5. S. Szpikowski, *Interacting Boson Model and its application to orthogonal solution of the five-dimensional spherical harmonic oscillator*, Materiały XVIII Zimowej Szkoły Fizyki Jądrowej, Bielsko–Biała 1980, str. 146–157.
6. S. Szpikowski, *Symmetries and supersymmetry in nuclear physics* in: „Spontaneous Symmetry Breakdown and Related Subjects”, s. 447–457, (Zimowa Szkoła Fizyki Teoretycznej, 18 luty–2 marzec 1985, Karpacz, ed. by World Scientific, 1985.
7. S. Szpikowski, *Symetrie i supersymetria w fizyce jądrowej*, Postępy Fizyki 39 (1988) 295–304, (wykład plenarny na Zjeździe PTF 1987 r.).

#### IV. BOOKS AND SCRIPTS

1. S. Szpikowski, *Mechanika kwantowa Część I*, stron 221, Wydawnictwo UMCS, Lublin 1969.
2. S. Szpikowski, *Mechanika kwantowa Część I – wydanie poprawione*, stron 218, Wydawnictwo UMCS, Lublin 1978.
3. S. Szpikowski, *Symmetries in Nuclei (Selected topics)*, Wydawnictwo Università Degli Studi di Trento, Italia, Trento 1984, stron 72.
4. S. Szpikowski, *Mechanika kwantowa Część II*, stron 211, Wydawnictwo UMCS, Lublin 1989.
5. S. Szpikowski, *Mechanika kwantowa Część II – wydanie poprawione*, stron 177, Wydawnictwo UMCS, Lublin 1994.
6. S. Szpikowski, *Elementy mechaniki kwantowej*, Wydawnictwo UMCS, Lublin 1999, stron 430.
7. S. Szpikowski, *Podstawy mechaniki kwantowej*, Wydawnictwo UMCS, Lublin 2006, stron 530.

#### V. POPULARIZATION OF SCIENCE

1. S. Szpikowski, *O cząstkach elementarnych*, Fizyka w Szkole, 5 (1959) 79–92.
2. S. Szpikowski, *Krótkozasięgowe oddziaływania i nowe grupy symetrii jądra atomu*, Postępy Techniki Jądrowej, 11 (1967) 541–544.
3. S. Szpikowski, *Opis układów mikro- i makroświata*, Sprawozdania Towarzystwa Naukowego KUL, 16 (1968) 208–210.
4. S. Szpikowski, *Czas w fizyce*, Fizyka w Szkole 22 (1976) 7–11.
5. S. Szpikowski, *Symetrie struktury jądra atomu*, Fizyka w Szkole, 25 (1979) 195–197.

#### VI. REFEREE'S REPORTS

1. Recenzja książki: E. Curie pt. „*Maria Curie*” Postępy Fizyki, 10 (1959) 479–480.

2. Recenzja książki: D.L. Andersona „*Odkrycie elektronu*” Kwartalnik Historii Nauki i Techniki, 12 (1967) 620–621.
3. Recenzja książki pod redakcją J. Hurwica: „*Wkład Polaków do nauki*”, Kwartalnik Historii Nauki i Techniki, 12 (1967) 829–830.
4. Recenzja książki: I. Asimowa „*Nauka z lotu ptaka*”, Kwartalnik Historii Nauki i Techniki, 13 (1968) 138–140.
5. Recenzja książki: „*Niels Bohr – his Life and Work as Seen by his Friends and Colleagues*”, Kwartalnik Historii Nauki i Techniki, 13 (1968) 456–459.
6. Recenzja książki: E. F. da Costa Andrade „*Sir Isaak Newton*” Kwartalnik Historii Nauki i Techniki, 14 (1969) 374–377.
7. Recenzja książki: G. Gamow „*Biografia fizyki*” Kwartalnik Historii Nauki i Techniki, 14 (1969) 535–535.
8. Recenzja książki: R. M. Page „*Powstanie radaru*” Kwartalnik Historii Nauki i Techniki, 14 (1969) 567–569.
9. Recenzja książki: J. Malarczyk „*Powstanie i organizacja Uniwersytetu Marii Curie-Skłodowskiej w świetle źródeł*” Kwartalnik Historii Nauki i Techniki, 14 (1969) 744–747.
10. Recenzja książki: I. I. Łagowski „*Budowa atomów*” Kwartalnik Historii Nauki i Techniki, 15 (1969) 164–165.
11. Recenzja książki: Kinga Strzelecka „*Życie pięknem było – rzecz o Kazimierzu Wilkomirskim*” „Akcent” 1996, str. 192–194.

#### VII TRANSLATIONS

1. Tłumaczenie z angielskiego książki N. Bohra pt. „*Fizyka atomowa a wiedza ludzka*”, (wspólnie z: W. Staszewski i A. Teske), PWN, Warszawa 1963, str. 1–152.
2. Tłumaczenie z angielskiego książki I. B. Cohena pt. „*Narodziny nowej fizyki*” Wiedza Powszechna 1964, str. 1–188.
3. Tłumaczenie z rosyjskiego artykułu A. T. Grigoriana: „*Podstawowe idee mechaniki Heinricha Hertza*” Kwartalnik Historii Nauki i Techniki, 13, (1968) 138–140.
4. Tłumaczenie pracy Ireny i Fryderyk Joliot-Curie: „*Piotr Curie i dzisiejsze drogi rozwoju nauki*” (wspólnie z: H. Świda-Szaciłowska), Kwartalnik Historii Nauki i Techniki, 13 (1968) 609–617.
5. Tłumaczenie na angielski pracy A. Teske: „*Elementary Proof of Einstein's Formula for the Mean Square Value of Displacement and for the Limiting Conditions*” The History of Physics, Ossolineum 1972, str. 75–79.
6. Tłumaczenie na angielski pracy A. Teske „*Methodological Aspects of the Investigation Concerning Brownian Movement*” The History of Physics, Ossolineum 1972, str. 80–89.

#### VIII. VARIA

1. *Uroczystości rocznicowe ku czci Marii Curie-Skłodowskiej i Mariana Smoluchowskiego w Lublinie*, Kwartalnik Historii Nauki i Techniki, 13 (1968) 226–228.
2. *Instytut Fizyki w XXX-leciu UMCS*, Informator UMCS, IX–X (1975) 15–19.

3. Czwartkowe spotkania wieczorne w Instytucie Fizyki, Informator UMCS 1 (1977) 1–2.
4. *Wywiad o pracach Zespołu Przedmiotowego Fizyki i Astronomii*, Fizyka w Szkole 23 (1977) 119–120.
5. *W świecie praw fizycznych* (wywiad), Głos Nauczycielski, 20.III.1977 r.
6. *Żywotne tradycje uniwersytetu europejskiego* (wypowiedź w ankiecie), Zeszyty Naukowe KUL 21 (1978) 106–109.
7. *Aktualny stan prac nad przygotowaniem do nowej szkoły 10-letniej*, Referat plenarny wygłoszony na XXVI Zjeździe Fizyków, Wrocław, wrzesień 1977 r. Prace Naukowe Instytutu Fizyki Politechniki Wrocławskiej 14 (1979) 123–127.
8. *Z prac Zespołu Przedmiotowego Fizyki i Astronomii*, Fizyka w Szkole 6 (1980) 372–373.
9. *XXVII Zjazd Fizyków Polskich w Lublinie* (wspólnie z: J. M. Zinkiewicz), Postępy Fizyki 33 (1982) 287.
10. *Włodzimierz Urbański (wspomnienie)* (wspólnie z: M. Piłat), Postępy Fizyki 33 (1982) 385.
11. *Słowo wstępne w tomie poświęconym profesorowi Maksymilianowi Piłatowi*, Annales UMCS, Sect. AAA, LLI (1995/1996) 9–12.
12. *Fizyka w 50-leciu Uniwersytetu Marii Curie-Skłodowskiej*, Wiadomości Uniwersyteckie, maj 1995.
13. *Rys historyczny rozwoju Katedry Fizyki Teoretycznej Uniwersytetu Marii Curie-Skłodowskiej w 60-lecie powstania*, Wiadomości Uniwersyteckie, maj 2006.

#### IX. REPORTS OF THE INSTITUTE OF PHYSICS UMCS

1. *A New Physical Basis for the Irreducible Representations of the Quasispin  $SO(5)$  Group* (wspólnie z: W. Berej), Raport IF UMCS, (1989) 15–16.
2. *Supersymmetry and Electromagnetic  $E2$  Transition* (wspólnie z: P. Kłosowski, L. Próchniak), Raport IF UMCS (1989) 25–26.
3. *On Nuclear Transfer in the Supersymmetric Model for Light Nuclei* (wspólnie z: L. Próchniak i P. Kłosowski), Raport IF UMCS (1989) 33–34.
4. *The IBM Interpretation of the First Excited  $3^-$  Nuclear States in Even–Even Nuclei* (wspólnie z: K. Zając), Raport IF UMCS (1989) 41–42.
5. *Supersymmetry Scheme  $j = 3/2$  for Nuclei  $32 \leq A \leq 40$*  (wspólnie z: L. Próchniak), Raport IF UMCS (1992) 43–44.
6. *Interacting Boson Model and  $3^-$  Levels in Cd and Te Isotopes*, Raport IF UMCS (1992) 55–56.
7. *The Elementary Method a Pairing Energy*, Raport IF UMCS (1993) 33–34.
8. *Supersymmetry in elementary particles and in nuclear physics*, Raport IF UMCS (1994) 43–44.
9. *Supersymmetry in the first half of the  $sd$ -shell* (wspólnie z: Y. S. Ling i L. Próchniak), Raport IF UMCS (1994) 45–46.
10. *Schematic application of the Supersymmetric Model to binding energies of exotic nuclei* (wspólnie z: K. Dietrich), Raport IF UMCS (1995) 39–40.
11. *Mass formula for  $sd$ -shell nuclei in the supersymmetric model* (wspólnie z: L. Próchniak i W. Berej), Raport IF UMCS (1996) 41–42.

