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MATHEMATICS AND MATHEMATICIANS AT THE JAGIELLONIAN UNIVERSITY (in a historical context)

IMUJ PREPRINT 2004/H1

I. Few words about the history of the University

The last king of the Piast Dynasty, Casimir the Great founded the University, *Studium Generale,* in Kraków, the capital of the Polish Kingdom, by his act dated on May 12, 1364. Initially the University had only three out of four classical medieval faculties : law, medicine and liberal arts (*Artes Liberales,Artium*). The development of the University practically stopped after the death of its founder in 1370. Further real development became possible in the last decade of the XIV-th century. In 1397 the faculty of theology was set up thanks to the Queen Jadwiga (now a saint of the Catholic Church). In that way the Kraków University became a full range medieval university having all the four classical faculties considered at that time necessary for forming a complete higher education institution.

The first king of the Jagiellonian Dynasty, Władysław Jagiełło renovated and extended the University by his act dated on July 26, 1400 according to the last will of his wife, the Queen Jadwiga.

Notice that the present name of the University of Kraków follows the name of the renovator, not the founder.

The middle of the XV century was the time of a significant acceleration of the development of the University (*Academy*). Programs (curricula) and several elements of the inner organization shape were changed; the *Artium* faculty, which included mathematics and astronomy took part in the process of these changes. In 1491 Nicolaus Copernicus (Mikołaj Kopernik) became a student of the Academia of Kraków.

The development of any school can be measured also by number of students. During the five decades 1450-1520 more than 14 300 students enrolled the University of Kraków.

Next centuries cannot be characterized univocally by expressing clear general positive or negative opinions. Some good periods interweaved with difficult and – sometimes – sad ones. Bright moments were results of reforms of the whole Polish education system implemented by Hugo Kołłątaj and Jan Śniadecki. The general framework of these reforms was outlined at the beginning of the last quarter of the XVIII century by the "Commission of the National Education" (in Polish: *Komisja Edukacji Narodowej*) which can be considered as the ministry

of education (probably the first such ministerial type institution in the World). Unfortunately the last decade of the XVIII century became the sad time of the partitions of Poland which lost its independence for more than 120 years. In particular the first half of the XIX century was a particularly difficult time for the University, when even the Polish language was formally eliminated during certain decades and replaced by German as an official teaching language. Fortunately the last third of the XIX century brought some positive changes, the repolonization process started, some outstanding professors (including mathematicians) came to Kraków and became members of the University teaching and research staff.

Poland regained the independence after the First World War. The new period of development was broken in 1939 when the country was invaded by the Nazi Germany. The occupants arrested professors of the Jagiellonian University and the Academy of Mining on the 6th of November 1939 (professors were "invited" to attend a lecture on national socialism ideology and then arrested and jailed in concentration camps). Many of them died there, those who saved their life were coming back to Kraków in 1940 and 1941. All Polish higher education institutions were closed (as well as secondary schools !). However the University worked as an "underground university" (as the University of Warsaw, Technical University of Warsaw /*Politechnika Warszawska*/ and the University of Poznań acting "illegally" in Warsaw).

Starting from 1945 the Jagiellonian University is again one of the best Polish universities (usually in recent rankings conducted by several bodies, including some journals and newspapers, the Universities of Kraków and Warszawa usually are on the first two places permuting their positions from time to time).

II. Mathematics at the Kraków University; a general outlook.

The knowledge about teaching of mathematics at the Casimir's *Studium Generale* at the very beginning of its existence is very poor. We know slightly more on the subject regarding the Jagiellonian Academy period. Programs (curricula) of the faculty of *Artes Liberales* are bound to have contained mathematics understood as the knowledge on calendar and some elements of arithmetic and geometry. We know that in particular *Algorithms (De Algoritmo)* of Johannes de Sacrobosco /John of Holywood/ (born about 1195 in England, died in 1256 in Paris) and some Latin versions of *Elements* (the first three of them) of Euclid were used. Let us add that the manual of Sacrobosco was also printed – in one of its edition – in Kraków in 1509.

The second half of the XV century was a period of a significant development of the whole University. In particular mathematics and astronomy represented a very high level. Among the best professors of mathematics and astronomy[1] there were Marcin from Żurawica called Marcin Król (born about 1422, died in 1453) and Marcin Bylica (about 1433-about 1493). The first reformed mathematical programs (curricula), the second cooperated with famous Johann Müller Regiomontanus (1436-1476) and being rather astronomer and astrologer than mathematician took care on astronomical equipment[2]. Marcin Król wrote *Algorismus minutiarum* and *Geometriae practicae seu Artis mensurationum Tractatus*. He was probably the first mathematician in Poland who treated seriously trigonometry using trigonometric functions. Scholars educated in Kraków had important positions abroad. For instance between 1448 and 1471 five of them headed university chairs at the Bologna University.

During next decades, including XVI century, many books on mathematics (mainly manuals) were written by authors from Kraków, (majority of them also printed in Kraków) and spread out within the University.

[1] At that time astronomy was practically tightly connected to astrology (considered in some sense as "applied astronomy") and very often there were chairs of astrology officially established. For instance Marcin Król had such a chair, as well as – later on – Johannes Broscius (mentioned below) and several others astronomers.

[2] Several astronomical instruments he donated to the University; they are now in the University Museum.

In 1543 *De revolutionibus orbium coelestium, Libri VI* of Copernicus (with an important trigonometric part) was printed in Nurnberg.

Unfortunately the significant acceleration in development of mathematics in Europe in the XVII century essentially was not reflected in Kraków. However, some very good mathematicians worked at the University, among them Johannes Broscius (*Jan Brożek*) (1585-1652), an outstanding mathematician and astronomer[3]. His scientific profile is outlined below.

Natural sciences and mathematics lowered their level during the period from the middle of XVII century to the sixties of the XVIII century. Reforms introduced by the "Commission of the National Education" mentioned above essentially improved the situation for some decades. These reforms were mainly results of an intensive activity of Hugo Kołłątaj[4] and Jan Śniadecki[5]. Unfortunately the middle of the XIX century again pushed back sciences, including mathematics. However, certain individual achievements of some mathematicians from that period should be noticed, as for instance remarkable results in the analytic number theory of Franciszek Mertens (1840-1927), acting in Kraków during the period 1866-1884 (his scientific profile is briefly outlined below) and some results of Stanisław Kępiński (1867-1908) acting for a short three years time at the Jagiellonian University.

The end of the XIX century brought a radical positive changes when two outstanding mathematicians: Kazimierz Paulin Żorawski (in 1885) and Stanisław Zaremba (1900) came to Kraków. They implemented modern mathematics (in the contemporary meaning of this term) in Kraków and in Poland in general and created a mathematical center. Their scientific activity should be described broadly; it will done below. Students of these two outstanding professors created scientific schools of complex analysis, differential equations and differential geometry.

About two decades later the famous mathematical schools of Warsaw and Lwów were established. Two of cofounders of these schools: Wacław Sierpiński (1882-1969) and Stefan Mazurkiewicz (1888-1945) made essential steps in their scientific careers in Kraków: Sierpiński got his Ph.D. degree in 1906, Mazurkiewicz reached the habilitation in 1919.

It should be added that between 1913 and 1917 an outstanding physicist Marian Smoluchowski (1872-1917) worked at the Jagiellonian University highly enriching scientific output of the University in physics and mathematics. Results of his research gave – among others – the foundation for the contemporary approach to a part of statistic physics (statistic processes) and probability theory.

On the 2nd of February 1919 a group of mathematicians created a society called first the *Mathematical Society* and shortly later the *Polish Mathematical Society.* Among 16 founders there were in particular: S. Banach[6] , L. Chwistek[7], A. Hoborski[8] F. Leja[9], O. Nikodym[10],

[3] In 1629 he was ordained a priest getting also the baccalaureate in theology and becoming professor of theology for a couple of years.

[4] Hugo Kołłątaj (1750-1812) a priest, educated in law and theology, a bright promoter of deep reforms of the whole Polish education system (introduced – with his participation – by the "Commission of National Education" mentioned above), a rector of the University of Kraków 1783-1786.

[5] Jan Śniadecki (1756-1830), a mathematician, an astronomer, the founder of the astronomic observatory in Kraków, an outstanding professor of the University of Kraków, in 1806 left Kraków becoming a rector of the University of Vilnius; more about him in the sequel.

[6] Stefan Banach (born on the 20th of March1892 in Kraków, died on 31st of August in Lwów) was at that time in Kraków studying mathematics at the University (guided mainly by S.Zaremba); he was already the author of two papers (one of them written with Hugo Steinhaus). His future bright career was developed at University of Lwów where he got his remarkable results basic for several parts of mathematics.

[7] Leon Chwistek (1884-1944), a logician, in the second half of twenties of XX century a lecturer at the Jagiellonian University, later on in Lwów, also a well known painter.

[8] Antoni Hoborski (1879-1940) is presented in the sequel.

[9] Franciszek Leja (1885-1979) is presented in the sequel.

A.Rosenblatt[11], J.Śleszyński[12] A.Wilk[13] and mentioned above S.Zaremba and K.P.Żorawski. S.Zaremba was elected to be the first president of the Society.

To the list of names of mathematicians acting in Kraków in two decades 1919 – 1939 presented above some others should be added. Tadeusz Ważewski (1896-1972), student of Zaremba, got his Ph.D.degree in Paris, created a scientific school of differential equations (called often the *Cracow School of Differential Equations*)[14]. Witold Wilkosz (1891-1941) had broad spectrum of interest including – first of all – mathematics and logic, philosophy, physics. He left valuable papers concerning in particular several subjects from analysis and differential geometry. Stanisław Krystyn Zaremba (1903-1990), the son of Stanisław Zaremba after a short period of the activity and getting the habilitation in Kraków worked in Wilno (Vilnius) at the Stefan Batory University; after the Second World War became professor in Canada and UK (Wales). He proposed a generalization of differential equations which *de facto* describes what is presently called differential inclusions[15]

The natural development of the University and chairs of mathematics in particular was dramatically interrupted in 1939. On November 6, 1939 members of the University staff, as well as professors of the Academy of Mining were arrested (as it was mentioned above). Among them were mathematicians: A. Bielecki[16], S.Gołąb[17], A.Hoborski, F.Leja, S.Turski[18], T.Ważewski and W.Wilkosz[19].

Antoni Hoborski died in the concentration camp Sachsenhausen on February 9 , 1940. The others came back to Kraków after different periods of imprisonment. All of them, after coming back, engaged themselves in several forms of "underground" teaching on different levels of education. For instance the war time academic activity of T.Ważewski in the framework of the "underground" University resulted with original remarkable papers. Simultaneously Ważewski's future successor on the university chair, Jacek Szarski[20] completed his studies getting the M.Sc. diploma in 1945.

After the end of war the research work in mathematics in Kraków concentrated mainly on analysis (first of all complex analysis and differential equations) and geometry.

In order to characterize generally the research activity in mathematics in fifties of the XX century in Kraków it is sufficient to present briefly three scientific schools created and lead by Franciszek Leja, Tadeusz Ważewski and Stanisław Gołąb.

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[10] Otton Nikodym ((1889-1974) was at that time a secondary school teacher, later on a lecturer at the Jagiellonian University, after the Second World War was continued his scientific career in USA.

[11] Alfred Rosenblatt (1880-1947) habilitated in 1913 presenting a dissertation concerning algebraic geometry, in 1929 got a position of an associated ("extraordinary" in the Polish terminology) professor, later on he went to Peru becoming in 1936 a professor at the University of Lima.

[12] Jan Śleszyński (1854-1931) a professor of mathematics and logic, came to Kraków in 1911.

[13] Antoni Wilk (1876-1940) an astronomer, a discoverer of four comets.

[14] His scientific portrait is outlined below.

[15] Independently and practically simultaneously similar generalizations were proposed by a French mathematician, André Marchaud. About 20 years later T.Ważewski, following the approach of S.K.Zaremba and A.Marchaud, showed that the optimal control theory can be based on the ideas of these two mathematicians.

[16] Adam Bielecki (1910-2002) at that time a lecturer (*adiunkt* in the Polish terminology); he got his Ph.D in 1935 at the Jagiellonian University under the supervision of W.Wilkosz, conducted research in analysis and geometry, after liberation from the concentration camp and coming back to Kraków active in the "underground" University, since 1947 a professor in Lublin at the Marie Curie-Skłodowska University.

[17] Stanisław Gołąb (1902-1980), a geometer, a student of Zaremba and Hoborski; his scientific profile is outlined below.

[18] Stanisław Turski (1906-1986), at that time a lecturer (*adiunkt*), after the Second World War a professor and a rector of Gdańsk Technical University (*Politechnika Gdańska*) and Warsaw University. His fields of interest: differential equations and – since late fifties of the XX century – computer sciences.

[19] Wilkosz was of a very poor health and was liberated after few days during the transport to Germany.

[20] Jacek Szarski (1921-1980), a student of T. Ważewski, the author of remarkable papers on differential equations and inequalities (further information presented below).

Franciszek Leja was the founder of the school of analytic functions. His ideas concerning in particular analytic functions of several variables, methods of extremal points and extremal functions were developed by his pupils and pupils of pupils. The direct successor of Franciszek Leja heading the chair is professor Józef Siciak who, after officially retiring (but being still – as everybody knows - very active) turned over this chair to professor Marek Jarnicki. Scientific roots originated in the school of Leja and Siciak have groups of mathematicians of younger generations concentrating now their efforts in particular on the approximations theory and some parts of algebraic geometry (see list of the chairs presented below).

Tadeusz Ważewski created the "Cracow School of Differential Equations". Among several subjects treated by Ważewski and his pupils and collaborators there were in particular: partial and ordinary differential inequalities and their applications, elements of qaulitative theory of differential equations, especially topological methods applied in the theory of differential equations. Among pupils and collaborators of Ważewski there were in particular J. Szarski (mentioned above), Z. Opial[21], C.Olech[22], W.Mlak[23], Z.Mikołajska-Mlakowa[24], A.Pliś[25], A.Lasota[26] and others. Among professors acting now at the Jagiellonian University there are also some pupils of Ważewski (compare the list of chairs).

Independently, Mirosław Krzyżański[27] worked efficiently in partial differential equations of the second order.

Stanisław Łojasiewicz [28], the author of famous theorem on *division by distribution* and the *Łojasiewicz inequality*, created a scientific school of real analytic geometry. His ideas are continued intensively (see the list of chairs).

Stanisław Gołąb who was a student of S.Zaremba and A.Hoborski, established after the Second World War a school of differential geometry. His pupils and grand pupils developed and continue to develop his ideas enriching them by adding modern impulses (compare the list of chairs). S. Gołąb stimulated also the development of the theory of functional equations, which is now investigated mainly by students of the former Gołąb's students at the Silesian University in Katowice and at the Academy of Mining and Metalurgy in Kraków.

It should be added that talking on the Kraków mathematical center after the Second World War we cannot limit our consideration to the University only since it is necessary to remember on mathematicians working at the Academy of Mining and Metalurgy and other higher educations institutions as well as - first of all – about the Institute of Mathematics of the Polish Academy of Sciences (Kraków branch). Several professors had positions in that Institute. Tadeusz Ważewski and Franciszek Leja headed sections in this Institute.

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[21] Zdzisław Opial (1930-1974), the author of valuable papers on differential equations and inequalities, fixed points theory, as well as on the history of mathematics, a talented teacher.

[22] Czesław Olech, a well known author of remarkable papers concerning many aspects of the theory of differential equations, for several years the director of Institute of Mathematics of the Polish Academy of Sciences, the chairman of the Organization Committee of the International Congress of Mathematicians, Warsaw 1982 (held in fact in 1983 because of political perturbations in Poland).

[23] Włodzimierz Mlak (1931-1994) wrote in particular papers on parabolic differential inequalities and equations and differential equations in Banach spaces; he was interested also in the theory of Hilbert spaces and wrote a monograph on that subject.

[24] Zofia Mikołajska-Mlakowa (1923-1993) the author of paper on – among others - the Ważewski topological method and differential equations with retarded arguments.

[25] Andrzej Pliś (1929-1991) the author of remarkable papers on differential equations, in particular discussing uniqueness questions for Cauchy problems for partial differential equations and applications of the topological methods of Ważewski. He introduced so-called characteristic strips of the second order for partial differential equations of the first order.

[26] Andrzej Lasota, the author of valuable papers on differential equations, fractals, applications of mathematics, biomathematics.

[27] Mirosław Krzyżański (1907-1965) came to Kraków from Wilno (Vilnius) in 1945.

[28] Stanisław Łojasiewicz (1926-2002); his scientific profile is presented below.

III. Scientific profiles of some outstanding mathematicians

JOHANNES BROSCIUS (JAN BROŻEK)
(1585 – 1652)

Johannes Broscius (*Jan Brożek*), born on the first of November 1565, became a student of the University of Kraków in 1604 or 1605 and obtained the *baccalaureate* in a very short time. In 1610 he got the degree of *master (magister) of liberal arts* and of *doctor of philosophy.* He was teaching mathematics very intensively. During the period of 1620-1623 he studied medicine in Padova getting in 1623 the *doctorate* in this field. In 1625 he was again in Kraków. He held a chair of astrology[29]. In 1629 he became a priest and got the *baccalaureate in theology.* From 1631 to 1638 he headed the library of the "University Greater College"- *Universitate Collegii Maioris*. Between 1639 and 1648 he was out of Kraków as a parish-priest in a small town Międzyrzecz relatively far from Kraków. In 1648, after coming back to Kraków, he presented a doctoral thesis in theology which gave him the *doctorate in theology* in 1650. In May of 1652 Broscius was elected a rector of the University. Unfortunately he died on the 21st of November of 1652 during a plague in Kraków.

Brożek was a generous donator. The University received from his donations books and money for many purposes. He was a book-lover; in his collection there were in particular three editions of the famous *De revolutionibus orbium celestium* of Copernicus printed in 1543, 1566 and 1617, books of Galileo Galilei, Johannes Kepler, John Napier (Neper) and others. The Brożek's rich library was after his death, according to his legacy, absorbed by the University library and now we can find remarks written three and half centuries ago by the former owner on margins of some pages of old books.

The outline of the *curriculum vitae* of Johannes Broscius presented above shows him as an extraordinary personality. In this essay we are interested first of all in what he has done in mathematics.

The first book published by Brożek already in 1610 was *Geodesia Distantiarum sine instrumento et Polybii locus obscurior geometrice explicatus* containing elementary applications of geometry for practical measurement in geodesic problems as well as more theoretical questions concerning – as we can express it in terms used presently – measuring of surfaces of two dimensional bounded domains with fixed length of boundaries. Next year he wrote a book on the planar regular figures (triangles, squares and hexagons) filling up the plane as we can express it using the present terminology. A start point for his considerations was an observation concerning shapes of wax cells built up by bees[30]. In 1620 he published a manual *Arithmetica integrorum* in which besides four elementary operations on integers several remarks on prime numbers are presented. Finally Brożek presented also logarithms expressing his admiration to the author John Napier (Neper)[31]in a very impressive way: *What a worthy prize will give mathematicians to you great Napier for the logarithms tables ? (Pro Logaritmorum tabulis tibi magne Nepere Praemia quae tribuent digna Mathematici ?).*

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[29] At that time astronomy and astrology had – as it was already pointed out above – in some sense "equal rights" and many true astronomers (and mathematicians) held university chairs of astrology. It should be added, however, that Broscius exchanging letters to Galileo Galilei used the title of an *ordinary professor of mathematics* when signing these letters.

[30] The original title of this book was: *Problema Geometricum. In quo ex Geometriae fundamentis vera & propria causa redditur, quare apes Hexagona figura fauos construant.*

[31] John Napier (Neper) (1550-1617). The first Napier's table of logarithms were published in 1614. The second publication on this subject containing the theory behind the tables was published in 1619 after the death of Napier. Notice that Brożek was aware of the newest results in mathematics when writing his book and he was able to judge properly the significance of them.
Let us add that logarithms were also introduced independently in 1620 by Joast Bürgi, a Swiss clock maker being interested in mathematics as an amateur.

Brożek obtained his most important achievements in the theory of numbers. He investigated prime and perfect numbers. In particular he spotted mistakes in articles of some other mathematicians.

This subject was treated in two dissertations *De Numeris Perfectis Discepatio* (Cracoviae 1637) and *De Numeris Perfectis Discepatio Altera* (in *Apologia pro Aristotele et Euclide*, part III, 1652). Brożek used ideas following the Erastotenes sieve method. Some Brożek's results are in fact certain special cases of the "small" theorem of Fermat[32]. Because of a natural limitation of the place it is impossible to present here all details.

Brożek was also interested in the history of sciences and – in particular – he wrote a book on Columbus and Copernicus. It should be added that he was a vigorous propagator of the ideas of Copernicus and expressed it openly which was not common (and sometimes even not easy) at that time.

JAN ŚNIADECKI
(1756-1830)

Jan Śniadecki was born on the 29th of August 1756 in a small city Żnin not far from Poznań. After completing his secondary education in Poznań he became in 1772 a student of the University of Kraków and started to study mathematics and physics. In 1775 he got the Ph.D. degree. The three years period 1778-1781 he spent traveling abroad, visiting Germany, Austria, Netherlands and France and enriching his knowledge in many fields, including mathematics, astronomy and meteorology. In particular in France he learned theory of probability and after coming back to Poland became the first who was able to teach this subject and did it successfully. He realized well how important was – new at that time – the theory, not only for the progress of mathematics itself but also for several applications, including – as he mentioned – banking and insurances. In 1748 he got the chair of so-called "higher mathematics" at the University of Kraków. He wrote five valuable manuals having several editions (some of them were translated into foreign languages). His original achievements in mathematics were rather small (as for instance certain contributions to spherical trigonometry), but his activity promoting sciences, in particular mathematics, astronomy and physics as well chemistry and biological sciences was of a great importance and resulted with important positive consequences for development of research and education in Poland. He was, for example, a founder of the astronomic observatory in Kraków. First of all he was involved very actively in the process of reforms of the University in the framework outlined by the "Commission of the National Education". He tightly cooperated with Hugo Kołłątaj the father of general reforms of the education system in Poland. In particular he reformed essentially curricula in sciences taught in Kraków.

Śniadecki expressed his view on necessity of building close links between research activity giving theoretical knowledge and applications, underlining the importance of that links in all schemes and frameworks of the university education. He claimed also vigorously that physics cannot be taught at the university level without a deep use of higher mathematics; such an opinion was not fully common among professors lecturing physics at that time. He was the founder of the astronomic observatory in Kraków.

The Jagiellonian University is – and should be – really deeply thankful to Jan Śniadecki for everything he did as a scientist, a teacher, an organizer and a reformer of the University.

Śniadecki was also interested in the history of sciences, especially of astronomy and propagated knowledge on Nicolaus Copernicus, his life and the heliocentric theory. The text of the lecture about Copernicus delivered in 1816 during a meeting of the "Warsaw Society of

[32] This theorem says (using our present formulation) : if p is a prime number and it does not divide a, then p divides the number $a^{p-1} - 1$. Fermat reached this result probably about 1640 but didn't published it at that time; thus results of Brożek were original and independent of results of Fermat.

Friends of Sciences" (*Towarzystwo Warzszawskie Przyjaciół Nauk*) published firstly in Polish was translated into several languages.

It should be added that several traces of the Śniadecki's work concerning philosophy of sciences as well as methodology of introducing and using national terminology in sciences are visible till now. In particular many terms in Polish mathematical terminology were introduced by Jan Śniadecki.

In 1787 Śniadecki was again abroad, in France and England, where he met a famous astronomer William Herschel[33]. These contacts were useful during organization of the astronomic observatory.

In 1805 Śniadecki moved to Wilno (Vilnius) becoming there a professor and a head of the astronomic observatory of the University. He became also a rector of the Vilnius University.

Jan Śniadecki died on 21st of November 1830 in a small village Jaszuny near Vilnius.

FRANCISZEK MERTENS
(1840-1927)

Franciszek Mertens was born on the 20th of March 1940. His mother Franciszka (Françoise) de Malignon, born in France, was a daughter of a Polish-French married couple, while his father was a Pole, Karol Mertens, a physician (surgeon) form a family having some old German roots. Hence it is not surprising that Franciszek Mertens spoke fluently Polish, German and French. He studied mathematics in Berlin during the period 1853-1860 at the time of Karl Weierstrass, Leopold Kronecker, Ernst Kummer and Elwin Bruno Christoffel. After getting there in 1864 the Ph.D. degree[34] he came to Kraków in 1865 and then went in 1884 to Graz in Austria (becoming there a rector the Graz Technical University) and ten years later to Vienna.

Mertens obtained his most important results in the analytic theory of numbers. It would be difficult and too much time consuming (as well as extending too much the volume of this essay) to present here these results in details. Instead the author of the present text allows himself to refer to the book *Development of Mathematics 1900-1950* edited by Jean-Paul Pier (Birkhäuser Verlag, Basel-Boston-Berlin,1994), where in the Chapter 8 written by Wolfgang Schwarz, all details can be found.

KAZIMIERZ PAULIN ŻORAWSKI
(1866-1953)

Kazimierz Paulin Żorawski was born on the 22nd of June 1866 in a small village Szczurzyn in the central part of Poland in a landlord family. He got the doctoral degree in 1888 at the University of Warsaw (at that time it was an University run by Russian occupants; thus the degree was called : *a candidate of sciences* according to the Russian terminology and systems of degrees). His scientific profile was essentially shaped during his stay in Göttingen and Leipzig under a supervison of Marius Sophus Lie. Following ideas of his master Żorawski started to work in the theory of continuous groups getting some results which now would be included into the theory of differential forms. These results allowed him to get the Ph.D. degree in 1891. After coming back to Poland Żorawski worked at the Technical University *(Szkoła Politechniczna*) in Lwów (Lviv) getting there the habilitation in 1892. In 1895 he came to Kraków. In 1917 was elected a rector of the Jagiellonian University when newly elected rector, Marian Smoluchowski (mentioned above) died almost immediately after the election. Żorawski moved to Warsaw in 1919 and spent there the rest of his life being

[33] William Herschel (1738-1822) an astronomer, discovered in 1781 the new planet Uranus.

[34] He was distinguished getting the doctoral diploma with: *eximia cum laude;* only 13 mathematicians received such a special distinction (*eximia cum laude* or *summa cum* laude) during the period 1810-1933.

very active in many fields, not only of the academic sphere (he was for instance a high functionary in the ministry of education). He died on the 23rd of January 1953.

His scientific activity concentrated mainly on: differential forms, integral invariants, kinematics and theory of solid body motions, differential equations and differential geometry. In particular he described a complete system of differential invariants of a surface in a three dimensional affine space.

Besides the results of the Żorawski's research activity, the most important consequences of his presence in Kraków was the creation, together with Stanisław Zaremba, of a true scientific center. Neither Żorawski nor Zaremba established any "classical" and "individual" scientific school of the type: "one master gathering pupils", but they built up a strong mathematical center. Pupils of them (in many cases there were simultaneously pupils of the both these masters) established later on their own strong schools.

STANISŁAW ZAREMBA
(1863-1953)

Stanisław Zaremba was born on the 3rd of October 1863 in a village Romanówka, now in Ukraine. He completed his technical studies at the Technology Institute in St. Petersburg getting an engineer diploma in 1886. Later he studied mathematics in Paris where he got in 1889 the Ph.D. degree presenting the thesis *Sur un problème concernant l'état calorifique d'un corps homogène indéfini.* In this paper Zaremba solved a problem proposed in 1858 by the Academy of Paris as a subject of an open competition for scientists. In 1861 Georg Riemann presented his solution but his paper was not awarded since there were only some outlines of proofs and the Academy did not find them sufficient. Zaremba showed that there were some cases omitted by Riemann and gave precise proofs for cases considered by Riemann. It seems to be obvious that this first real scientific success decided in some sense about his future interest in partial differential equations mainly of the so-called "mathematical physics".

After 1889 he was teaching mathematics in secondary (high) schools in Digne, Nimes and Cahors. In this period he collaborated with Paul Painlevé and Eduard Goursat. In 1900 he came to Kraków being nominated a so-called *extraordinary professor*[35] at the Jagiellonian University. He became an *ordinary professor* in 1905. Zaremba served as the Dean of Faculty of Philosophy during an extremely difficult academic year 1914/1915 at the beginning of the World War I. In 1903 he was elected a "correspondent member" of the Academy of Sciences and Art[36] and in 1926 full ("active") member of it (at this time already Polish Academy of Sciences and Arts). The Jagiellonian University offered him in 1935 the title of the *honorary professor* . Earlier he got *doctorates honoris causa* of the Jagiellonian University (1930), Caen University (1932) and University of Poznań (1934). He was a member of several scientific societies. Zaremba was active in the Polish Mathematical Society from the very beginning (it was mentioned already that he was the first President of the Society). Now one of the scientific prizes of the Polish Mathematical Society bears his name.

Zaremba died in Kraków on the 22nd of November 1942.

[35] According to the Polish university tradition there are two professorship positions: an *extraordinary professor* (practically equivalent to the position of *associate professor* in USA) and an *ordinary professor* (*full professor*).

[36] In Polish: "*Akademia Umiejętności* (the Polish name is translated as the Academy of Sciences and Arts since the word "umiejętności" is not equivalent to the word "science" and has a broader meaning) established in 1872 became in 1919 the Polish Academy of Sciences and Arts (*Polska Akademia Umiejętności*). Its activity was interrupted in 1952, reactivated in 1989. It is acting now independently on the Polish Academy of Sciences (*Polska Aademia Nauk*) established in 1952. There are two categories of members : "correspondent" and "active" (=ordinary, full).

Among important results obtained by Zaremba those concerning the Dirichlet problem for the elliptic equation

$$\Delta u + \xi u + f = 0$$

were probably the most significant.

Jean Mawhin wrote that *according to Bouligand Zaremba's contribution to the development of the theory of the Dirichlet problem is the same as that of Poincaré and Lebesgue.*

Zaremba gave the first in the literature example of such a domain for which a linear Dirichlet problem has no solutions. He used a method of orthogonal projections in Dirichlet problem theory[37].

In 1897 he wrote a paper dealing with successive approximations for solutions of a non-linear equation

$$\Delta u = f(x,y,z, \partial u/\partial x, \partial u/\partial y, \partial u/\partial z).$$

This paper as well as another paper concerning the theory of the Green function is cited in the *Enzyklopädie der Mathematischen Wissenschaften, band II (Leipzig 1907),* in the article of A.Sommerfeld, *Randwertaufgaben in der Theorie der partiellen Differentialgleichungen,* where a canon of the theory of elliptic equations is presented.

It is impossible to refer all his results on the Dirichlet problem and related problems; we have to limit ourselves to the above general remarks.

He treated also several other problems, as for instance those of Neumann and Fourier. He built up basic preliminaries for the theory of reproducing kernels[38]. In 1915 he wrote a paper on so-called spherical wave giving an estimation for

$$\int (grad^2 u) d\tau$$

where u is a solution of this equation. The idea of Zaremba used there was applied later on by Friedrichs and Levy in order to get known (now) integral inequalities satisfied by general solutions of hyperbolic equations. These inequalities have been generalized by Juliusz Schauder and became some fundamental elements in the survey of the theory of hyperbolic equations.

The Fourier equation

$$\Delta_x u - \partial u / \partial t = 0 \qquad (u = u(t, x))$$

was the subject of Zaremba's presentation during the International Congress of Mathematicians in Strasbourg in 1920[39]

Another fields of Zaremba's interest concerned some problems of the theoretical physic, as for instance visco-elasticity and relaxation. He was interested also in foundation of mathematics, wrote manuals on theoretical mechanics, several papers popularizing mathematics.

As it was already mentioned above, Satnisław Zaremba and Kazimierz Żorawski created a scientific center. It would be difficult to overvalue the results of the activity of Zaremba in stimulating personal scientific development of young researchers who later on built up their own scientific schools.

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[37] The example of the non-existence and the method of orthogonal projections are mentioned among the main achievements of the first half of the XX century in *Development of Mathematics 1900-1950, ed. Jean-Paul Pier 1994* (referred above).

[38] See for instance the article by N.Aronszajn *Theory of reproducing kernels,* Trans. Amer. Math. Soc., 68 (1950),337-404.

[39] Lat us recall that the International Mathematical Union (IMU) was founded at that time (precisely: the founding document was signed on the 20th of September 1920). Countries-founders were: Belgium, Chechoslovakia, France, Greece, Italy, Japan, Poland, Portugal, Serbia, United Kingdom, United States. Poland was represented by Zaremba.

FRANCISZEK LEJA
(1885-1979)

Franciszek Leja was born on the 27th of January 1885 in a small village Grodzisko Górne in the South-East part of Poland. He studied mathematics at the Univeristy of Lwów during the period 1904-1909. He attended in particular lectures delivered by Józef Puzyna[40]. These lectures stimulated Leja's choice of his future scientific specialization. Franciszek Leja became later an outstanding specialist in the field of his master. Leja attended also lectures on theoretical physics by Marian Smoluchowski, who was at that time in Lwów (and came later on, in 1913, to Kraków; compare sect. II above). After passing university exams necessary for teaching mathematics and physics in secondary schools Franciszek Leja obtained a position of a high school teacher in one of *gymnasiums* in Kraków. In 1911 he wrote a paper on non-Euclidean geometry (published in "reports of the director of the fourth gymnasium"; such reports were published at that time yearly). After reading this paper Kazimierz Żorawski arranged a scholarship (founded by the Academy of Sciences and Arts) which allowed Leja to spend the academic year 1912/1913 in Paris. Leja met there P.Fatou, J.Hadamard, P.Montel and H.Lebesgue. In that way Żorawski introduced to mathematics a young scientist who became soon an outstanding member of the Kraków center. In 1913 Leja undertook duties of an assistant at the Jagiellonian University and started to prepare his doctoral thesis which was successfully defended in 1916. In 1922 Leja got the habilitation at the Jagiellonian University. During the period of twelve years from 1924 to 1936 he worked at the Technical University of Warsaw (*Politechnika Warszawska*). In 1936, after S.Zaremba retired, Leja took over one of the chairs at Jagiellonian University. He was arrested on November 6, 1939 together with other professors of the University and the Academy of Mining and imprisoned in the Sachsenhausen concentration camp (cf. the section I above). After coming back to Kraków in 1940 he went to his home village and took part in the "underground teaching" on the secondary school level. In 1945 Leja was again in Kraków taking part in revitalization of the University. He retired in 1980 but didn't stop his scientific and teaching activity. The author of this essay remembers professor Leja being 90, coming weakly to our Institute of Mathematics in order to conduct the seminar. Franciszek Leja died in Kraków on the 11th of October 1979.

Franciszek Leja founded in Kraków a scientific school of analytic functions. His pupils and "grand-pupils" created their own schools. Professor Józef Siciak continued the traditional seminar and developed the idea of Leja; pupils of Siciak are now professors and develop their research activities (compare the list of chairs and below).

In order to recall the scientific output of Leja let us list shortly the domains of his interest and fields in which he received his main results. Among them there were: topological groups, power series and analytic functions of several variables, convergence of double series, summability of divergence series, sequences of polynomials of analytic functions, methods of extremal points and extremal functions.

Extremal points and functions theory allowed Leja to get important results concerning – among others – Green function on the complex plain, constructions of solutions of some Dirichlet problems, characterization of regular points for Dirichlet problems, characterization of some classes of holomorphic functions. Leja gave a new proof of Hartogs theorem on functions separatly holomorphic and characterized series of homogenous polynomials of two variables having non-empty domain of convergence. He was the first who introduced formally the notion of a topological group.

[40] Józef Puzyna 1856-1919), a specialist in the theory of analytic functions, an author of a pioneer monograph on this subject (vol. 1 published in 1898, vol.2 in 1900).

Let us complete this very short presentation by quoting some sentences from the introduction to the book of .B.D.Staff and V.Troik, *Logarithmic potentials with external fields,* "Grundlagen der mathematischen Wissenschaften", Springer Verlag, 1997:

The external field problem has its origin in the work of C.F.Gauss, and is sometimes referred to as the Gauss variation problem. *O.Frostman investigated the problem and the Polish school headed by F.Leja made important contribution during the period 1935-1960 that have greatly influenced the present work (...)*[41]

TADEUSZ WAŻEWSKI
(1896-1972)

Tadeusz Ważewski was born on the 24th 1896 in a small village Wygnanka in the south-east part of Poland (now in Ukraine) died on the 8th of September 1972 in Rabka-Zaryte about 80 kilometers to the south from Kraków.

He became a student of the Jagiellonian University in 1914 beginning his studies in physics and then, following the advice of professor Stanisław Zaremba he switched to mathematics. Between 1921 and 1923 Ważewski was in Paris continuing his studies up to the doctorate which he got in 1924 presenting a thesis on locally connected continuums containing no closed curves. Members of the doctoral exam committee were Émile Borel, Arnoud Denjoy and Paul Montel. After coming back to Kraków he got the habilitation in 1927. Ważewski taught during a short period in secondary schools in Kraków, after that from 1923 to 1926 was an assistant at the Academy of Mining and then since 1926 worked at the Jagiellonian University. He was arrested, being at that time an extraordinary professor[42] on November 6, 1939 together with professors of the University and the Academy of Mining and imprisoned in the Sachsenhausen concentration camp. In 1940 he came back to Kraków and took part in the scientific and teaching activity of the "underground" University. In 1945 nominated an ordinary (full) professor. He was elected a member of the Polish Academy of Sciences and Arts[43], in 1952 became a correspondent member of the Polish Academy of Sciences and then in 1958 a full member of it. The Polish Mathematical Society offered him in 1967 a honorary membership[44], in the same year the Jagiellonian University gave him the honorary doctorate (*doctorate honoris casusa*).

Tadeusz Ważewski was an outstanding scientist and a talented teacher. Among his many important results were those concerning: partial differential equations of the first order (in particular the best estimations of domains of existence of solutions of Cauchy problems), ordinary and partial differential inequalities, some asymptotic properties ("asymptotic coincidence") of solutions of pairs of ordinary differential equations, first integral questions (existence of first integrals for partial differential equations of the first order in some simply connected subset of the plane), successive approximations (in several versions), topological methods in differential equations (in particular the famous *Ważewski retract theorem and the Ważewski topological method*), optimal control theory and several parts of the classical analysis (like for instance problems concerning implicit functions, an uniform proof of all the cases of de l'Hospital rule). The basic ideas of the *Ważewski topological method* were in fact used by Conley in order to built up his index theory. It should be pointed out that now "grand-pupils" of Ważewski develop his ideas, concerning originally applications of general topology methods in differential equations, on an "upper level" by using methods of algebraic topology

[41] This quotation closed also a beautiful essay of Józef Siciak about his master Franciszek Leja published (in Polish) in *Złota Księga Wydziału Matematyki i Fizyki UJ, Kraków2000* (the title in Polish: *Golden Book of the Faculty of Mathematics and Physics of the Jagiellonian University);* the text presented here is based essentially on information taken from the essay of Siciak.

[42] Compare the foot note 35 above.

[43] Compare the foot note 36 above.

[44] He was a President of the Society (1959-1961).

(including the Conley index and its modifications) in differential equations and dynamical systems.

Because of a natural limitation of the place it is practically impossible to present – even only the most important – results of Ważewski. The author of this essay would like to refer to *Tadeusz Ważewski Selected Papers* published by the Institute of Mathematics of the Polish Academy of Sciences[45].

Tadeusz Ważewski was the founder of scientific school called often *the Cracow school of differential equations* (compare the section II above).

ANTONI HOBORSKI
(1879-1940)

Antoni Maria Hoborski was born on the 1st of April 1879 in Tarnów. He completed his studies in mathematics at the Jagiellonian University in 1901 and worked as a teacher of secondary schools in Kraków and other cities of the region of South Poland. In 1908 he got the Ph.D. degree under the supervision of S.Zaremba presenting the doctoral thesis on the parabolic equation $v_{xx} + v_{yy} = v_t$. In 1909 and 1910 he was in Paris and Göttingen (attending lectures of Felix Klein and David Hilbert). In 1911 he got the habilitation at the Jagiellonian University. In 1919 was nominated an *ordinary professor*[46] of the Academy of Mining in Kraków becoming the first rector of this Higher School. He continued simultaneously the lecturing at the University.

Hoborski was arrested on the 6th of November 1939 and imprisoned in the Sachsenhausen concentration camp. On the 8th of February 1940 he got a formal decision permitting him to leave the camp, he died there next day because of a tragic illness and weakness.

His fields of interests were differential equations and differential geometry. He wrote several manuals. His main contribution to the development of mathematics in Kraków consisted of creation of a scientific school of differential geometry and the organization of a group of mathematicians working at the Academy of Mining which itself was also organized mainly by him.

STANISŁAW GOŁĄB
(1902-1980)

He was born in 1902 in Travnik (Bosnia). After completing the secondary education in Kraków he entered the Jagiellonian University in 1920 and studied mathematics till 1924. He worked as a secondary school teacher and simultaneously – already, since 1922 - as an assistant at the Academy of Mining. The period 1928-1931 he spent abroad (in Italy, Czechoslovakia, Germany and the Netherlands). In Holland he worked under the supervision of Jahn Arnoldus Schouten writing a dissertation *Über verallgemeinerte projektive Geometrie* which was accepted in 1931 at the Jagiellonian University as a doctoral thesis. He worked at the Academy of Mining having there a full position till 1955 (with a sad interruption between 1939 and 1945) when he became an *ordinary professor*[47] at the Jagiellonian University and the head of the chair of geometry. He was arrested on the 6th of November 1939. After coming back to Kraków in 1940 Gołąb undertook teaching at the "underground" University.

Gołąb was interested mainly in geometry, especially in differential geometry, and the most his important papers concern several sub-domains of that field, as for instance: theory of geometrical objects, Minkowski and Finsler spaces and several problems of the projective geometry. In collaboration with van Schouten he proposed some rules for the local tensor calculus ("Kern-Index-Methode"). Gołąb was one of founders of the theory of geometrical objects. He introduced to that theory certain basic notions and classified several familes of

[45] *Tadeusz Ważewski. Selected Papers,* edited by Czesław Olech, Andrzej Pelczar, Zofia Szmydt, PWN-Polish Scientific Publishers, Warszawa 1990.

[46] See the footnote 35

[47] see the footnote 35

objects. He stimulated also research in the theory of functional equations undertaken by some of his pupils. He was also interested in applications of mathematics.

Stanisław Gołąb established a scientific school continuing in that way the work of Antoni Hoborski. His pupils and "grand-pupils" work now successfully at the Jagiellonian University and in other higher education institutions in Poland.

Stanisław Gołąb died in Kraków on the 30th of April 1980 in Kraków.

JACEK SZARSKI
(1921-1980)

Jacek Szarski was born on the 6th of February 1921 in Kraków. He begun his studies at the Jagiellonian University since the autumn of 1938 and continued them during the Second World War under a supervision of Tadeusz Ważewski who came back from the concentration camp in March of 1940. The education, at the "underground" University enabled him to get the M.Sc. diploma in 1945. He obtained the Ph.D. degree very soon in the autumn of 1945. The doctoral thesis[48] contained an important result: there exist a function Q of the class C^∞ defined on the plane such that every solution of the equation

$$\partial z / \partial x + Q(x, y)\partial z / \partial y = 0$$

defined and continuously derivable on the whole plane must be a constant function. This result generalized an earlier result on the existence of first integrals of Ważewski (mentioned above). Szarski reached the habilitation in 1947 after presenting a dissertation on partial differential inequalities of the first order. He was nominated an *extraordinary professor* in 1954 and 8 years later an *ordinary professor*[49]. In 1966 he took up the chair of Analysis after Tadeusz Ważewski was retired. Szarski was a dean of the Faculty of Mathematics, Physics and Chemistry (1956-1958), vice-rector of the University (1964-1966) and headed the University mathematics during two decades 1857-1977 (it was first the "Section of Mathematics" and later, since 1967, the Institute of Mathematics).

Jacek Szarski obtained valuable results in the theory of differential equations and – first of all – differential inequalities. He wrote a monograph *Differential Inequalities* (PWN, Warszawa, 1st ed. 1965, 2nd ed. 1967), the first such a complete presentation of the theory in the literature of the subject. He treated differential-functional equations and inequalities. In the catalogue of his results there are theorems on partial parabolic differential inequalities of the second order. He wrote also papers dealing with certain particular technical problems modeled by some integro-differential equations and – together with Ważewski on certain problem on radiology.

Jacek Szarski was known as a splendid popularizer of mathematics and as a very talented and popular academic teacher.

He died in the 21st of February 1980 in Zakopane.

STANISŁAW ŁOJASIEWICZ
(1926-2002)

Stanisław Łojasiewicz, born on the 9th of October 1926, became a student of the Jagiellonian University in 1945. He begun working as an assistant–volunteer already in 1947.

The first subject of his research was the theory of differential equations. In particular his doctoral dissertation concerned asymptotic behavior of solutions of some differential equation near a singular point[50]. Later he started to work in the theory of distributions. A fundamental

[48] The title of the thesis written in Polish (translated into English) was: *On some integral problem concerning the equation* $\partial z/\partial x + Q(x,y)\,\partial z/\partial y = 0$ *defined on the whole plane.*

[49] Compare the footnote 35.

[50] The original title of this work published almost five years after its presentation as the doctoral thesis was: *Sur l'allure asymptotique des integrals du système d'équations différentielles au voisinage de point singulier* (Ann. Polon..Math.,1(1955),34-72)

result obtained by Łojasiewicz in this field was the theorem on *division by distribution* positively answering to the following question: given an open subset U of $\mathbf{R}^n$, a real analytic function f and a distribution T on U, can we find a distribution S such that $fS = T$? The essential role in the proof of this theorem is played by some inequality called now the *Łojasiewicz inequality*. Let F be an analytic function defined in an open subset G of the n-dimensional real space $\boldsymbol{R}^n$ and let Z be the set of zeros of this function restricted to a subset Q of G. Let us consider a point a of Q. Then there are N and C such that

$$|F(x)| \geq C\,dist(x,Z)^N$$

in a some neighborhood a.

Developing the ideas used in the proof of the theorem on *division by distribution* Łojasiewicz came to some new concepts and created theory of *semi-analytic sets*. A subset G of a real analytic manifold M is *semi-analytic* if every point a of M has a neigbourhood Q such that

$$A \cap Q = \cup_i \cap_j A_{ij} \quad (i \in I, j \in J),$$

where I and J are finite sets of indices for every i, j:

$$A_{ij} = \{x \in Q : f_{ij}(x) = 0\} \quad \text{or} \quad A_{ij} = \{x \in Q : f_{ij}(x) > 0\}$$

for some analytic function f_{ij} defined on Q. The theory of semi-analytic sets, or - in a rather broader sense - the *semi-analytic geometry* was presented by Łojasiewicz in a monography *Ensemble semi-analytiques* (Institut des Hautes Études Scientiques, Bures-sur-Yvette, 1965). He gave also in this monograph a foundation of the *semi-algebraic geometry*. In this monograph one can find roots of the *sub-analytic geometry*. Omitting a formal definition of sub-analytic sets let us mention only that they arose because of the fact that projections of analytic sets are not necessary analytic and sub-analytic sets were introduced thus in order to get a class of sets closed with respect to the operation of projection. In 1962 Łojasiewicz formulated an important theorem on the triangulation of analytic sets. Let us add that in this year he was nominated an *ordinary professor* at the Jagiellonian University.

Summarizing briefly what was mentioned above, one can say that Stanisław Łojasiewicz was the author of the basic concepts of the theories of semi-analytic, semi-algebraic and sub-analytic sets. Nobody dealing with these theories can omit his results included in his fundamental papers and books.

Besides original results he made a significant effort simplifying and clarifying many parts of real analytic geometry.

Another field of Łojasiewicz interest was differential analysis, in particular theory of singularities and sufficiency of jets. In 1967 he gave a beautiful proof (completely independent on other ones) of an important theorem of Weierstarss-Malgarnge-Mather essential in the theory of singularities and the Thom's theory of catastrophes. This proof illustrates some characteristic attribute of the scientific activity of Łojasiewicz. He was convinced that ways of proving theorems (especially important ones) should be as simple as possible and it is a worthy challenge to simplify every such reasoning which is complicated, seems to be "artificial" or "non-natural". Proofs presented by Łojasiewicz are precisely elaborated to perfection and surely can be called natural.

Stanisław Łojasiewicz was awarded with several prizes, medals and orders, prestige memberships of academies and societies. He was in particular a full member of the Polish Academy of Sciences, Polish Academy of Sciences and Arts, Pontifical Academy of Sciences. He lectured in many countries at famous world mathematical centers. He delivered an invited lecture on semi-analytic sets during the International Congress of Mathematicians in Nice (1970). His death on the 14th November 2002 interrupted preparations of a comprehensive monograph on the analytic and sub-analytic geometry expected to be published together with M.A.Zurro-Moro.

Stanisław Łojasiewicz created a scientific school; members of it work now at the Jagiellonian University as well as at several other universities in Poland and abroad.

IV. The present picture of the Institute of Mathematics

The Institute of Mathematics is a part of the Faculty of Mathematics and Computer Sciences. Its director is professor Roman Srzednicki, vice-directors: professor Jerzy Ombach and dr. Krzysztof Ciesielski.

There are nine chairs[51] named below together with lists of subjects of their main interest.

Functional Analysis (professor Franciszek H. Szafraniec).

- The operator theory (unbounded subnormal operators, operators of the mathematical physics, Toeplitz operators, composition operators, operator semi-groups, invariant subspaces),
- Methods of Hilbert spaces (moment problems, interpolation problems, "sampling theory")
- Quantum harmonic oscillator and generalizations,
- Spaces with indefinite inner product,
- Linear relations in Hilbert spaces,

Analysis (professor Marek Jarnicki)

- The pluripotential theory (existence and regularity of solutions of the Monge-Ampère equation, Dirichlet problem, Green function and its application in the complex analysis, pluripolar sets),
- Complex holomorphic pseudo-distances and pseudo-metrics,
- Extensions of analytic functions and functions separately analytic,
- Domains of holomorphy.

Real Functions (professor Wiesław Pawłucki).

- Geometry of *o*-minimal structures,
- Differential properties of sets with singularities,
- Properties of algebras of differentiable functions,
- Hardy fields,
- Asymptotic solutions of analytic equations,
- Lebesgue measure as a polynomial on the Banach space of sets.

Geometry (professor Jacek Gancarzewicz).

- Affine differential geometry,
- Theory of foliations,
- Symplectic geometry,
- Hyperkähler geometry,
- Natural bundles and operators,

Algebraic and Analytic Geometry (professor Tadeusz Winiarski).

- Real and complex algebraic geometry (geometry of polynomial mappings, groups of automorphisms, Gröbner bases, classification of algebraic surfaces, geometric degree),
- Complex analytic geometry,
- Algebra (commutative algebra, elements of the matrix theory).

Mathematical Problems of Physics and Technics (professor Bolesław Szafirski).

- Evolution equations – deterministic and stochastic approach,
- Dynamical entropy, Markov operators, iterated function systems,
- Black-Scholes equation.

Computer Methods and Statistics (professor Jerzy Ombach).

- Statistics,
- Theory of stochastic processes (stochastic differential equations, time series),

[51] The list of chairs is presented in the alphabetical order of names in Polish.

- Hyperborbolic dynamical systems; pseudo-orbit tracing property, inverse shadowing,
- Generic properties of dynamical systems,
- Didactics of mathematics.

Differential Equations (professor Andrzej Pelczar).

- Qualitative theory of differential equations and dynamical systems (methods of algebraic topology in differential equations theory, impulsive dynamical systems, differential inclusions, general processes),
- Some aspects of the theory of differential-functional equations,
- Computer assisted treatment of differential equations and dynamical systems.

Theory of Approximations (professor Wiesław Pleśniak).

- Pluripotential theory, applications to the theory of polynomial and rational mappings,
- Polynomial approximation and continuation of smooth functions,
- Pluriregularity in *o*-mnimal structures
- Polynomial inequalities in Banach spaces,
- Minimal projections in Banach spaces,
- Contractive sets in Banach spaces.

There is also another unit - the section of Financial mathematics (dr hab. Armen Edigarian) with the following fields of interest:

- Interest-rate derivative securities ,
- Stochastic differential equations,
- Optimal capital structures,
- Actuarial mathematics and capital market models.

Some parts of this text are based on the essays from the book "*Złota Księga Wydziału Matematyki i Fizyki Uniwersytetu Jagiellońskiego" (Golden Book of the Faulty of Mathematics and Physics of the Jagiellonian University),* Kraków 2000, and the articles : Wiesław Pawłucki, *Stanisław Łojasiewicz (1926-2002),* Wiadomości Mtematyczne, 39(2003),183-190, Andrzej Pelczar, *O początkach współczesnej Matematyki w Polsce (On the beginning of the contemporary mathematics in Poland),* Proceedings of the Congress of Polish Mathematicians, Warszawa, Jachranka, June 21-26, 1994, 13-31.

Kraków, June 4, 2004.