1 A Short Biography of L. A. Santaló

Some Biographical Data

L. A. Santaló was born in Girona on October 9, 1911, and died in Buenos Aires on November 22, 2001. He began studying at the *Scholastic Group*, where his father was a teacher. He then moved to the *Institute*, of which he preserved a long-lasting memory. At the age of 16 he went to study in Madrid, where he was later to obtain his degree at the Faculty of Mathematics in 1934. Here he entered into scientific relations with professors Julio Rey Pastor and Esteve Terradas, who both exercised a decisive influence on him. Indeed, it was on their advice that he went to Hamburg to work with Wilhelm Blaschke. While he was there he also met Chern, Wu, Varga, Petkantschin and others. At that time, Blaschke was engaged in the study of geometric probabilities, thereby originating what he himself was to term *Integralgeometrie*.

In 1936, sponsored by Pedro Pineda, Santaló obtained his Ph. D. with a thesis on Integral Geometry, [36.1].

After the Spanish Civil War, Santaló moved to France, and with the assistance of Rey Pastor obtained a position at the University of Litoral, Rosario, Argentina. It was at that time that the *Instituto de Matemática* under the direction of Beppo Levy was created at the University of Litoral, and Santaló was named as Assistant Director, a position he held until 1949, during which time he helped to create the mathematical journal *Mathematicae Notae*.

In 1948 was awarded a grant from the Guggenheim Foundation to study in Princeton and Chicago. In 1949 he obtained a post at the University of La Plata and supervised his first doctoral thesis. In 1957 he became a full professor of the Faculty of Exact and Natural Sciences at the University of Buenos Aires, where he remained until his retirement. Beginning in 1955, he visited Spain several times, maintaining in particular a close relationship with Vidal-Abascal, who was responsible for introducing the study of the Integral Geometry into Spain.

More Important Distinctions for His Educational and Research Work

In Spain

- *Corresponding Academic* of the Royal Academy of Exact, Physical and Natural Sciences of Madrid, 1955.

- *Corresponding Academic* of the Royal Academy of Sciences and Arts of Barcelona, 1970.
- Doctor *Honoris Causa* from the Polytechnical University of Catalonia, 1977.
- *Corresponding Member* of the Institute of Catalan Studies, 1977.
- *Prince of Asturias* Prize for Scientific and Technological Research, 1983.
- *Narcís Monturiol* Medal for Science and Technology from the Government of Catalonia, 1984.
- Doctor *Honoris Causa* from the Autonomous University of Barcelona, 1986.
- Doctor *Honoris Causa* from the University of Sevilla, 1990.
- Awarded the Medal of the University of Valencia, 1993.
- *Corresponding Academic* of the Academy of Sciences of Canarias, 1993.
- Cross of Sant Jordi, from the Government of Catalonia, 1994.
- *Cross of Alfonso X*, granted by King Juan Carlos and given by the ambassador of Spain in Argentina.
- *Honorary Member* of the Royal Spanish Mathematical Society, 1999.
- The University of Girona creates the Santaló's Chair, 2000.
- *Honorary Member* of the Catalan Mathematical Society, 2000.

In Argentina

- National Prize of Culture, 1954.
- Argentina Scientific Society Award, 1959.
- *Academic* of the National Academy of Exact, Physical and Natural Sciences of Buenos Aires, 1960. Secretary (1972–1976). Vice-president (1976–1980). President (1980–1984), Honorary Academic (1997).
- *Corresponding Academic* of the National Academy of Sciences of Cordoba, 1961.
- Doctor *Honoris Causa* from the National University of Nordeste, Argentina, 1977.
- Severe Vaccaro Foundation Prize, 1977.
- *Honorary Professor* from the National University of La Plata, 1979.
- Doctor *Honoris Causa* from the National University of Misiones, 1982.
- Doctor *Honoris Causa* from the National University of Tucumán, 1983.
- Inter-American *Prize of Sciences, B. A. Houssay*, 1986.
- *Academic* of the National Academy of Educatión, Buenos Aires, 1989.
- Doctor *Honoris Causa* from the University of San Juan, 1991.
- *National Consecration Prize* of the Culture Secretariat, Buenos Aires, 1992.
- Doctor *Honoris Causa* from the University CAECE of Buenos Aires, 1992.
- Doctor *Honoris Causa* from the University of Buenos Aires, 1992.
- Doctor *Honoris Causa* from the University of Morón, 1992.
- *Honorary Member* of the Argentina Scientific Society, 1994.
- *Gold Rose Prize* of the Foundation Tapia by the *trajectory in benefit of the education of excellence*, Buenos Aires, 1994.
- *Jose Manuel Estrada Prize* for *Teacher of Argentine Sciences*, Arquidiocesana Commission for Culture, Buenos Aires, 1995.
- *Konex of Honor Prize* (posthumous), 2003.

Other Distinctions

- *Corresponding Academic* of the National Academy of Exact, Physical and Natural Sciences of Lima (Perú), 1945.
- Member of the International Statistical Institute, Holland, 1979.
- *Honorary Member* of the Mathematical Society of Paraguay, 1982.
- *Honorary Member* of the Academy of Sciences of Latin America, Venezuela, 1983.
- *Honorary Member* of the Royal Statistical Society of London, 1984.
- *Honorary Member* of the Latin American Society of the History of Sciences and the Technology, 1984.
- *Corresponding Academic* of the Academy of Sciences of Chile, 1986.
- *Honorary Life Member* of the International Society of Stereology, Germany, 1994.
- *Badge Tribute* for persistence and dedication to the Mathematical Education, Blumenau, Brazil, 1994.
- *Academic* of the New York Academy of Sciences, USA, 1997.

2 Scientific Work of L. A. Santaló

Analysis of Santaló's scientific work reveals certain fundamental characteristics; his considerable powers of abstraction, his brilliant geometric intuition, his surprising clarity of exposition and his outstanding gifts as a disseminator of science. It is therefore hardly surprising that his work should have had such profound repercussions in the specialized scientific community and in society in general. The international mathematical community regards Santaló as one of the great geometers of the 20th century, comparable with Blaschke, Chern and Hadwiger, among others. His contribution to the development of Integral Geometry throughout the 20th century is exceptional, both from the mathematical perspective and from the point of view of the applications of his theories to the applied sciences. One may state with complete certainty that men such as Santaló will always be necessary for the development of Mathematics, its applications and its dissemination.

Santaló was a person who always showed a lively interest in the problems surrounding him. We the Editors of Professor Santaló's Selected Papers had the honour and the pleasure of knowing him personally and of enjoying his friendship. To each one of us, albeit on different occasions, he conveyed his personal and scientific experiences, both while he was in Spain and during his prolonged sojourn in Argentina, the country where he carried out practically the whole of his activity as a professor and researcher.

This activity covered various scientific fields; among them, research into Differential Geometry, Integral Geometry and Theoretical Physics. He was also greatly drawn to the Teaching of Mathematics at all levels (in particular, at Secondary School and University level), and his cherished wish was to bring Mathematics closer to society in order to make them understandable to the scientific community in general. Close analysis of his research papers shows that from the very beginning that he was concerned with making clear the applications of Mathematics in general, and Integral Geometry in particular, to other applied sciences, especially to the Theory of Geometric Probability, to Statistics and to Physics.

His long career as a researcher (more than fifty years), his global vision of the problems that aroused his interest, his professional gifts, his vocation, his perseverance and his enormous capacity for work enabled him to produce a body of scientific work of great value. According to the references that appear in Zentralblatt MATH and Mathematical Reviews, he wrote scientific papers that alone amount to approximately 2000 pages. In addition, he authored twenty-five books, all with an exceptional educational value, both from the teaching and learning points of view. As a complement to his professional activity, and beginnng in the 1970s, he wrote many articles devoted to mathematical dissemination and education. Every time he participated in meetings of this nature, he was greatly contented and radiated optimism to all those who attended his seminars and talks.

The content of his publications covers a wide range. We believe that it is very difficult, not to say impossible, to arrive at an objective classification of his work according to fields and specialities, since very often many of his papers could very well be assigned to several of them at once. Nevertheless, with the aim of showing the different lines of research to which he devoted his work, we have divided these Selected Papers into five main Chapters (see Section 6 in Contents). We also believe it is useful to accompany the contents of each of these sections by a short commentary, each one drawn up by a specialist. However, as a possible Historical overview, we also believe it apposite to situate briefly that part of his work dealing with invariant measures within the scientific context in which they were produced, since the concept of kinematic density is present in much of that work. In addition to the articles and papers that figure in this Selection, Santaló also wrote many others, some of which are of great interest.

Analysis of the history of the development of Integral Geometry enables us to state that the origin of this speciality is to be found in the so-called "*Buffon's Needle problem*", posed by this naturalist in his famous *Essai d'Arithmetique Morale*, written in the late 18th century. In this regard, Crofton's formulas, contained in his well-known article *On the theory of local probability*, should also be taken into consideration.

This type of problem, which at first appeared to be simply a game or a mathematical pastime, led to the development of a mathematical theory in its own right, due mainly to the work of Poincaré, Blaschke and his school. Among the most prestigious pupils belonging to Blaschke's school, we may mention, among others, Chern, Santaló, Wu, Petkanschin and Varga, but most of all the first two. All of them turned up for some time at Hamburg. Thus it was that in the first third of the 20th century, when Integral Geometry emerged as a specialized field of mathematics with its own content, Blaschke and his school, with Chern and Santaló in particular, employed Cartan's moving reference method in their work. This would turn out to be the most powerful tool in the development of the whole of Santaló's mathematical work, and in much of Chern's work too. Written in this language, these works on Integral Geometry have provided the basis for this discipline right down to our own time, the study of which remains obligatory for all those reseachers who are interested in this speciality.

When in a problem of probabilities the set of possible cases has the power of the continuous, this is known as "*Geometric Probability*". This definition coincides with the classical one, the number of cases being replaced by the "*measure*", which is required to be defined for each type of set, and which, furthermore, can vary if the measure is changed. By analysing the quotient (favourable cases / possible cases) in the problem of Buffon's Needle we find that infinite possibilities exist. These possibilities can be parametrized and identified again as points in the plane, so that one has as many positions as points, and thus it seems quite obvious that the area can be used to "*measure*" or "*count*" the number of points. As Santaló states in [76.1], "*in order to apply the idea of probability to randomly given elements that* *are geometric objects (such as points, lines, geodesics, congruent sets, movements of affinities) it is first necessary to define a measure for such sets of elements*".

Thus in the problems posed by geometric probabilities, it is towards the geometric interest in itself that the mathematician feels drawn, and he addresses these problems without concerning himself with whether or not there may be an underlying concept of probability. The discussion about what measure it is necessary to chose is related with the group that determines the geometry of the problem in the sense of F. Klein's Erlangen programme. This is the mathematical reason why in Santaló's work the properties of Lie groups and homogeneous spaces figure so explicitly. E. Cartan, by looking for differential invariants for the Lie transformation groups rather than delving into problems of geometric probabilities, was the first to justify the concept of density and to generalize it to sets of straight lines and planes in space. He proved that the property of such a density must be that its value does not change when all the lines and planes considered are subject to a movement in space. Obviously, density depends on the group used at each moment. Thus, Cartan paved the way from the theory of continuous groups towards the theory of geometric probabilities. It should be noted that invariance with respect to the group of movements is equivalent to stating, for example, that all straight lines have the same behaviour.

According to Santaló, the basis of Integral Geometry consists fundamentally of four words: *probability, measure, group and geometry*. Indeed, some of his most important results come from measuring directly in the group. For instance, he identifies all the positions of a particular figure in the plane with the movements that carry an initial given figure to each of the possible positions. The formulas found thereby are known as kinematic formulas, because they express this idea of movement, even though the group may not specifically be the group of movements. Kinematic density in Euclidean space was introduced by Poincaré. In modern terminology, this is the Haar measure for the group of movements. One of the basic problems in Integral Geometry is to obtain explicit formulas for the integrals of geometric quantities with respect to kinematic density in terms of well-known integral invariants. As Santaló pointed out in the introduction to [67.5], Integral Geometry consists of three steps that constitute Integral Geometry in Blaschke's original sense:

1. The definition of measure for sets of geometric objects with certain properties of invariance;
2. The evaluation of this measure for some particular sets;
3. The application of the result obtained to arrive at statements of geometric interest.

In 1976, Santaló published an outstanding book entitled "*Integral Geometry and Geometric Probability*", [76.1], which we refer to as *The Encyclopedia*, since it contained almost all the basic existing bibliographic information on this speciality available at the time of publication. This book, which is regarded as a masterpiece of Classical Integral Geometry, was translated into Russian and Chinese. In order to understand much of Santaló's work, a basic knowledge of the theory of differenciable manifolds and of Lie groups is required. This is because that all Integral Geometry in Blaschke's, Chern's and Santaló's sense is grounded on the analysis of invariant properties under the effect of groups that act as homogeneous spaces, since as is well-known these spaces always admit a differentiable manifold structure.

In accordance with the ideas of Poincaré, Cartan and Blaschke, Santaló defines and analyses densities and measures in homogeneous spaces. To this end, he uses very simple mathematical foundations; let G be a Lie group and H a closed subgroup of G; then G/H admits a differentiable manifold structure. Chern gives a necessary and sufficient condition for the existence of an invariant measure on G/H in terms of the constants of the structure of G. Santaló extends this result, giving conditions for the existence of a differentiable non-null form on G/H and whenever it is G-invariant. He defines such a form as a "*density*" on G/H, and by integration it leads to an "*invariant measure*" on the homogeneous space: under the hypothesis that G acts transitively on a manifold, and the invariant density (if it exists) is unique except for a constant factor. Basically, Integral Geometry in Santaló's and Chern's sense rests on the following basic result: "*A necessary and sufficient condition for a form* ω, *verifying* $\omega(X, \ldots) = 0$ *for any* X *belonging to the Lie algebra of* H, *to be a density for* G/H *is that its exterior differential vanishes*".

Santaló employed this result repeatedly to construct densities and invariant measures on different homogeneous spaces, which enabled him to measure geometric objects with a high degree of generalization. This theorem was used and generalized in various contexts by various authors.

Following Hadwiger, Bonnesen and Fenchel, Santaló introduced the quermass-integrals[1]. Among other results, Santaló obtained the measure for sets of r-planes intersecting a convex set. This measure enabled him to obtain interesting formulas on the geometric probability of subspaces intersecting a convex set in terms of the integrals of the mean curvatures, thereby generalizing the results of Blaschke and his school to Euclidean spaces of arbitrary dimension.

Thus, the combination of problems arising from processes involving geometric elements together with probabilistic questions paved the way to Stochastic Geometry, thus called by Kendall and Harding in 1974, which is currently applied to different fields in Pure Mathematics (such as the theory of convex bodies) and in Applied Mathematics. Santaló also expressed his interest in this speciality in a series of intersting articles, such as that he wrote on random mosaics.

Perhaps Santaló's most important contribution to the applied sciences was his having laid the mathematical foundations for the creation of a new applied science: *Stereology*. This he did with a series of papers published over many years. However, it appears that the origin of Stereology is to be found in [43.2]: *On the probable distribution of corpuscles in a body, deduced from the distribution of its sections and analogous problems*.

In the 1970s, Elias put forward the following definition: "*Stereology deals with a set of methods for the exploration of 3-dimensional space, when only sections of two dimensions are known, by solid sets or their projections*". According to Santaló, the basic objective of Stereology is "*to determine the measure of the distribution of convex*

[1] Averaged measures, which, by the Steiner Formula, can be indentified with the integrals of mean curvatures of a convex set in Euclidean space.

particles distributed randomly in 3-dimensional Euclidean space from the measure of the distribution of its sections with random figures of known form (for example, a convex body, a cylinder, a plane, a band or a line). Stereology is an interdisciplinary science that draws together subjects as seemingly disparate as Biology, Engineering, Minerology, Metallurgy, Biomedicine, Geometry and Statistics".

By applying the techniques of this speciality, volumes, areas, lengths, number of particles, forms of bodies, etc., can all be estimated. This enables Stereology to be successfully applied in other apparently disparate sciences. Santaló was also interested in Integral Geometry in spaces of constant curvature. He wrote many interesting papers on this subject, perhaps the most fundamental being [52.4]. He extends many of the properties of Euclidean Integral Geometry to these spaces; in particular, one might mention Steiner's formula, its generalizations and properties, as well as the Cauchy and Kubota formulas. Furthermore, Santaló defines new concepts; for example, for the case of negative curvature, convexity by subsets that behave like Euclideans sets; specifically, he introduces convex sets by horospheres.

Integral Geometry in Riemannian spaces of non-constant curvature cannot be based on the same principle as that use for constructing Integral Geometry in spaces of constant curvature, because in general such spaces do not admit a transitive group of transformations that preserve the metric, neither do they apply geodesics in geodesics. Therefore, density for a set of geodesics cannot be defined by the property of being invariant under a certain group of transformations. Nevertheless, as Santaló points out, one may adopt another approach and define a measure for sets of geodesics and sets of points, which, although it is not invariant under a group, has properties of invariance that make it interesting from the geometric point of view. Santaló defines an invariant measure for geodesics and analyses its properties and consequences.

The term Integral Geometry was also used in the mathematical bibliography in a sense apparently different from that of the Blaschke, Santaló and Chern school. In the early 20th century, J. Radon proved that a differentiable function on 3-dimensional Euclidean space can be explicitly determined by means of its integrals on the planes.

The mathematical theory of Radon's Transform was built around this idea, and is related to the Fourier transform of a function. The classical intepretation of X-rays can also be regarded as an attempt to reconstruct properties of a 3-dimensional body using the projection of such rays onto a plane. The modern geometric interpretation of the action of X-rays, as well as many other elements currently employed in Medicine, can be performed using Radon's transform.

While the two concepts of Integral Geometry (the schools of Blaschke, Santaló and Chern on the one hand, and those of Gelfand and Helgason on the other) appear not to be related, Guillemin points to the fact that they are. Smith, Solmon and Wagner (Bull. Amer. Math. Soc. 83 (1977), 1227–1270) published an exceptional article entitled: *Mathematical and practical aspects of the problem of reconstructing objects from radiographies*. The mathematics employed in this article is fundamentally the theory of Integral Geometry in Gelfand and Helgason's sense. Thus, it is possible to explain all the medical activities of Tomography from a mathematical point of view. This branch of Analysis and of Geometry has undergone considerable development in recent years. At present, it appears to be one of the most interesting lines of research in the field of Integral Geometry. During the last years of his life, Santaló was wont to attend all the congresses held on this subject and invited us to study and explore this new technique more deeply.

Perhaps as a result of the time he spent in Princeton and Chicago, Santaló pubished a series of interesting articles on the Theory of Relativity and Theoretical Physics which we have decided to omit from this Selection, since they depart from the main lines of his mathematical research.

THE EDITORS

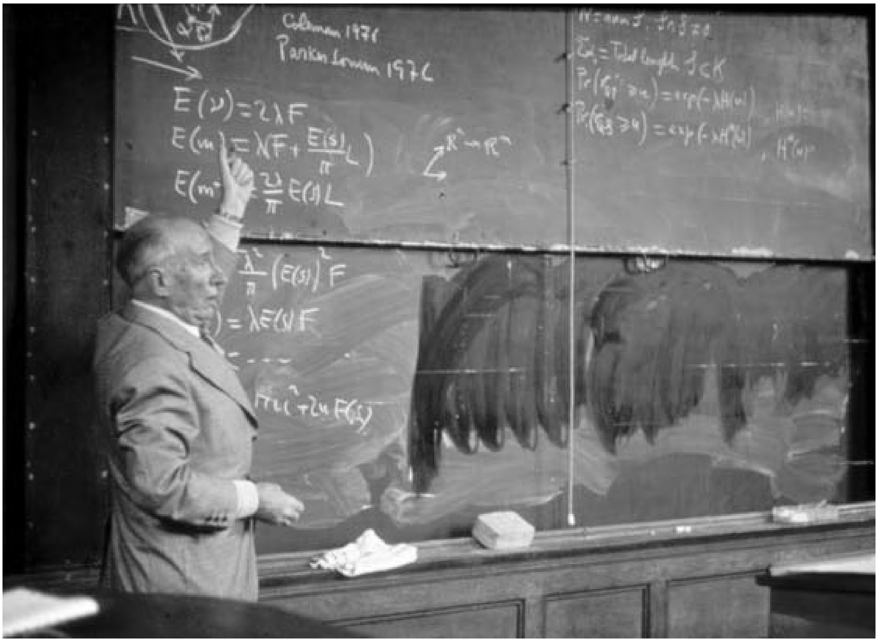
3 Some Photographs of L. A. Santaló

Dean Fac. San Juan, Santaló, J. Rey Pastor, E. Corominas.
San Juan (Argentina) 1941.
(Courtesy of Instituto de España (Madrid))

Front row: A. Sagastume, A. Durañona, G. D. Birkhoff, J. Rey Pastor, L. A. Santaló.
Buenos Aires, July 25, 1942.
(Courtesy of Instituto de España (Madrid))

Santaló at home (1988).
(Courtesy of Santalo's family)

With Vidal-Abascal in Santiago de Compostela. 2^{nd} International Colloquium on Differential Geometry. Santaló presents the work [67.1].
(Courtesy of Vidal-Abascal's family)



Explaining [78.3] at the Buffon Bicentenary Symposium. Paris, June 1977.
(Courtesy of L. M. Cruz-Orive)

Buffon Bicentenary Symposium. Jardin des Plantes, París, June 1977.
(Courtesy of L. M. Cruz-Orive)

With Cruz-Orive. Buffon Bicentenary Symposium.
Jardin des Plantes, París, June 1977.
(Courtesy of L. M. Cruz-Orive)

With S. M. King Juan Carlos I, receiving the Prince of Asturias Prize
in Technical and Scientific Research, 1983.
(Courtesy of Santalo's family and Casa Real of Spain)

This price was established in 1981 and is one of the most prestigious given in Spain to members of the internacional scientific community. Santaló is the only one that had received this Prize for his contribution to pure mathematics.

Giving a talk.
(Courtesy of Santalo's family)

With Naveira in Santaló's office. Fac. Ciencias Matemáticas, Buenos Aires, September 1997.
(Courtesy of A. M. Naveira)

Santaló and his wife Hilda Rossi in the celebration
in the anniversary of its daughter Claudia, 1997.
(Courtesy of Santalo's family)

4 L. A. Santaló's Published Work

1934

[34.1.r][2] Some combinatorial problems, (Spanish); *Matemática Elemental* **3** (1934), 21–22.

[34.2.r] Area generated by a segment which moves keeping itself normal to a line and describing a developable surface, (Spanish); *Rev. Mat. Hisp.-Amer.* **9** (1934), 101–107.

[34.3.r] Developable surfaces through a straight line, (Spanish); *Las Ciencias*, **I** (1934), 1–7.

1935

[35.1.r] Some properties of spherical curves and a characteristic of the sphere, (Spanish); *Rev. Mat. Hisp.-Amer.* **10** (1935), 9–12.

[35.2.r] An integral formula for convex figures in the plane and the space, (Spanish); *Rev. Mat. Hisp.-Amer.* **10** (1935), 209–216.

1936

[36.1.r]* Integral Geometry 7: New applications of the concept of the kinematic measure in the plane and the space, (Spanish); *Rev. Acad. Ci. Exact. Fis. Nat.* (Ph. D. thesis), Madrid **33**, (1936), 451–504.

[36.2.r] Some problems referring to geometrical probabilities, (Spanish); *Rev. Mat. Hisp.- Amer.* **11** (1936), 87–97.

[36.3.r] Integral Geometry 4: On the kinematic measure in the plane, (Spanish); *Abh. Math. Sem. Univ. Hamburg* **11** (1936), 222–236.

[36.4.r] Integral Geometry 5: On the kinematic measure in space, (Spanish); *Actualités Sci. Industr. Hermann* **357**, París, 1936.

[36.5.r] Curves on a surface which hold the condition $\delta \int (k, \tau) ds = 0$, (Spanish); *Rev. Mat. Hisp.-Amer.* **11** (1937), 129–138.

1937

[37.1.r] Integral geometrie 15: Fundamental formula of the kinematic measure for cylinders and moving parallel planes, *Abh. Math. Sem. Univ. Hamburg* **12** (1937), 38–41.

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[2] The notation $[\alpha.\beta.\gamma]$ denotes: α the year of the publication, β the order in that year and γ means book (b), research (r), general interest (g) or education (e). Also the references indicated with (*) are those chosen for the "Selecta".

1939

[39.1.r] Integral Geometry of unlimited figures, (Spanish); *Publ. Inst. Mat. Univ. Nac. Litoral*, Rosario **1** (1939), 1–58.

1940

[40.1.r]* On some problems of geometric probabilities, (French); *Tôhoku Math. J.* **47** (1940), 159–171.

[40.2.r]* A theorem on sets of parallelepipeds with parallel edges, (Spanish); *Publ. Inst. Mat. Univ. Nac. Litoral*, Rosario **2** (1940), 49–60.

[40.3.r] Integral Geometry 31: On mean values and geometric probabilities, (Spanish); *Abh. Math. Sem. Univ. Hamburg* **13** (1940), 284–294.

[40.4.r] Integral Geometry 32: Some integral formulae in the plane and in the space; *Abh. Math. Sem. Univ. Hamburg* **13** (1940), 344–356.

[40.5.r] A demonstration of the isoperimetric property of the circle, (Spanish); *Publ. Inst. Mat. Univ. Nac. Litoral*, Rosario **2** (1940), 37–46.

[40.6.g] On some geometrical problems concerning aviation, (Spanish); *Boletín Matemático*, Buenos Aires **13** (1940), 66-71.

[40.7.g] On continuous probabilities, (Spanish); *Ciencia*, Méjico **1**, 1940.

1941

[41.1.r]* A generalization of a theorem of Kubota on ovals, (German); *Tôhoku Math. J.* **48** (1941), 64–67.

[41.2.r]* Proof of a theorem of Bottema on ovals, (German); *Tôhoku Math. J.* **48** (1941), 221–224.

[41.3.r]* A theorem and an inequality referring to rectificable curves, *Amer. J. Math.* **63** (1941), 635–644.

[41.4.r]* Curves of extremal total torsion and *D*-curves, (Spanish); *Publ. Inst. Mat. Univ. Nac. Litoral*, Rosario **3** (1941), 131–156.

[41.5.r] Some infinitesimal properties of plane curves, (Spanish); *Math. Notae* **1** (1941), 129–144.

[41.6.r] Generalization of a problem of geometrical probability, (Spanish); *Rev. Un. Mat. Argentina* **7** (1941), 129–132.

[41.7.r] Nicolas Tartaglia and the resolution of the equation of third order, (Spanish); *Math. Notae* **1** (1941), 26–33.

[41.8.r] A system of mean values in the theory of geometric probabilities, (Spanish); *Revista Ci. Lima* **43** (1941), 147-154.

[41.9.g] The mathematics and language, (Spanish); *Asoc. Cult. Conferencias*, Rosario, 1941.

[41.10.g] Probability and its several applications, (Spanish); *Asoc. Cult. Conferencias*, Rosario, 1941.

[41.11.r] The mean value of the number of parts into which a convex domain is divided by *n* arbitrary straight lines, (Spanish); *Rev. Un. Mat. Argentina* **7** (1941), 33–37.

1942

[42.1.r]* Integral formulas in Crofton's style on the sphere and some inequalities referring to spherical curves, *Duke Math. J.* **9** (1942), 707–722.

[42.2.r]* On the isoperimetric inequality for surfaces of constant negative curvature, (Spanish); *Univ. Nac. Tucumán Rev.* **3** (1942), 243–259.

[42.3.r]* Supplement to the note: A theorem on sets of parallelepipeds with parallel edges, (Spanish); *Publ. Inst. Mat. Univ. Nac. Litoral*, Rosario **3** (1942), 202–210.

[42.4.r] On the concept of curvature of a surface, (Spanish); *Math. Notae* **2** (1942), 165–184.

[42.5.r] An integral formula concerning convex figures, (Spanish); *Rev. Un. Mat. Argentina* **8** (1942), 165–169.

[42.6.r] On certain varieties of the type of a developable in Euclidean space of four dimensions, (Spanish); *Publ. Inst. Mat. Univ. Nac. Litoral*, Rosario **4** (1942), 3–42.

[42.7.r] Some mean values and inequalities relating to curves on the sphere, (Spanish); *Rev. Un. Mat. Argentina* **8** (1942), 113—125.

[42.8.r] Isaac Newton and the binomial theorem, (Spanish); *Math. Notae* **2** (1942), 61–72.

[42.9.r] Some properties of the twisted curves in the affine differential geometry, (French); *Portugaliae Mat.* **3** (1942), 63–68.

[42.10.r] Surfaces of constant negative curvature, (Spanish); *Univ. Nac. Tucumán Rev.* **3** (1942), 243–259.

[42.11.r] (With Cosnita, Thebault and Court). Problems and solutions. Advanced problems: Problems for solution: 4036–4039. *Amer. Math. Monthly* **49** (1942), 340–341.

[42.12.g] Possibilities of interplanetary flight, (Spanish); *Rev. Ingeniería y Arquitectura*, Rosario, 1942.

[42.13.e] What must be done for the progress of mathematics in Argentina?, (Spanish); *Publ. Facultad Ci. Mat., Físico-Químicas y Nat. Apl. a la Industria*. Univ. Nac. Litoral **34** (1942), 41-45.

[42.14.g] Probability and its several applications. Conference published by *Asoc. Cult. Conferencias*, Rosario, 1942.

1943

[43.1.r]* Integral Geometry on surfaces of constant negative curvature, *Duke Math. J.* **10** (1943), 687–709.

[43.2.r]* On the probable distribution of corpuscles in a body, deduced from the distribution of its sections, and analogous problems, (Spanish); *Rev. Un. Mat. Argentina* **9** (1943), 145–164.

[43.3.r] (With Fritz). Problems and solutions: Advanced problems: Solutions: 4036. *Amer. Math. Monthly* **50** (1943), 397–399.

[43.4.r] A characteristic property of the circle, (Spanish); *Math. Notae* **3** (1943), 142–147.

[43.5.r] Some inequalities between the elements of a triangle, (Spanish); *Math. Notae* **3** (1943), 65–73.
[43.6.r] On the osculating conic section at an ordinary point of a plane curve, (Spanish); *Rev. Un. Mat. Argentina* **9** (1943), 53–60.
[43.7.r] On some systems of linear equations and their determinants, (Spanish); *Math. Notae* **3** (1943), 129–184.
[43.8.g] Brief history and current state of some chimera and fantasies of human being, (Spanish); *Rev. Centr. Estud., Fac. Ciencias Matemáticas*, Rosario, 1943.
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http://www.springer.com/978-3-540-89580-0

Selected Works
Santaló, L.A. - Naveira, A.M.; Reventós, A. (Eds.)
2009, XII, 854 p., Hardcover
ISBN: 978-3-540-89580-0