

Functional Analysis and Evolution Equations

The Günter Lumer Volume

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Birkhäuser
Basel · Boston · Berlin

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2000 Mathematical Subject Classification 35, 39B, 45G, 45K, 46F, 47D, 53C, 65M, 65N, 70G, 76D, 80A, 91B, 92D, 93D, 93E

Library of Congress Control Number: 2007933910

Bibliographic information published by Die Deutsche Bibliothek
Die Deutsche Bibliothek lists this publication in the Deutsche Nationalbibliografie;
detailed bibliographic data is available in the Internet at <<http://dnb.ddb.de>>.

ISBN 3-7643-7793-9 Birkhäuser Verlag, Basel – Boston – Berlin

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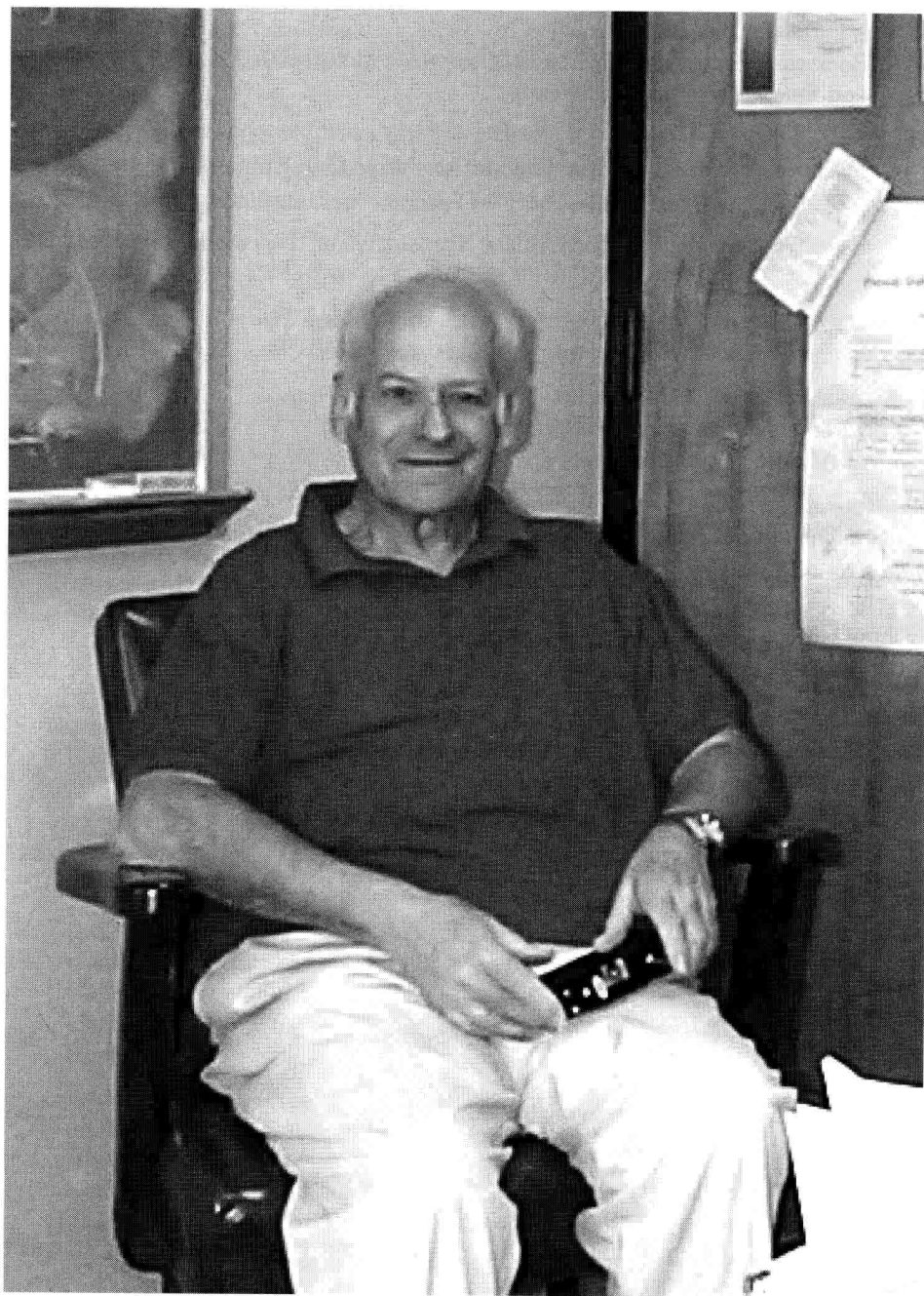
© 2008 Birkhäuser Verlag AG
Basel · Boston · Berlin
P.O. Box 133, CH-4010 Basel, Switzerland
Part of Springer Science+Business Media
Printed on acid-free paper produced of chlorine-free pulp. TCF ∞
Printed in Germany

ISBN 978-3-7643-7793-9

e-ISBN 978-3-7643-7794-6

9 8 7 6 5 4 3 2 1

www.birkhauser.ch



Günter Lumer (1929–2005)

Life and Work of Günter Lumer

Günter Lumer was born in Frankfurt, Germany in 1929. With Nazism on the rise, the Lumer family left Germany in 1933 and settled in France, where Günter received his early education. Then, in 1941, the Lumer family fled once again, this time to Uruguay, where Günter would become a citizen.

Possessing what would be a life-long passion for mathematics, Günter graduated in 1957 with a degree in electrical engineering from the University of Montevideo. In fact, while at Montevideo, he was in the research group of Paul Halmos, who would later dedicate a page to Günter in his book *I Want to be a Mathematician: an Automathography*. Günter's first paper "Square roots of operators," a joint work with P. Halmos and J.J. Schäffer, appeared in 1953 in the *Proceedings of the American Mathematical Society*.

In 1956, Günter received a Guggenheim fellowship to study at the University of Chicago. There he received his Ph.D. in Mathematics in 1959; his dissertation was entitled *Numerical Range and States* and was written under the supervision of Irving Kaplansky, thus earning himself a place among a long lineage of mathematicians connected to Kaplansky.

Following Chicago, Günter Lumer held positions at UCLA (1959–1960), Stanford University (1960–1961), University of Washington (1961–1974), University of Mons-Hainaut (1973–2005), and the International Solvay Institutes for Physics and Chemistry in Brussels (1999–2005).

Günter Lumer was a creative and prolific mathematician whose works have great influence on the research community in mathematical analysis and evolution equations. His scientific activities greatly contributed to the standing of the Belgian Universities in general and the University of Mons-Hainaut in particular. In 1976, supported by the Belgium National Science Foundation, Günter founded a contact group with the goal of organizing research and exchange meetings in the fields of Partial Differential Equations and Functional Analysis. From the 1990s on, building on the success of this group, Günter became a driving force and leading contributor to several large-scale projects sponsored by the European Community. The resulting conferences on *Evolution Equations* created a lasting network supporting international research collaboration. These activities, combined with Günter's relentless energy and love for mathematics, were at the origin of the breath-taking development of the field of evolution equations and the theory of operator semigroups after the pioneering book of Hille and Phillips from 1957.

In particular, between 1992 and 1997 he co-organized the *North West European Analysis Seminar* that was held in 1992 at Saint Amand les Eaux (France), in 1993 at Schloss Dagstuhl (Germany), in 1994 at Noordwijkerhout (The Netherlands), in 1995 at Lyon (France), in 1996 at Glasgow (United Kingdom) and in 1997 at Blaubeuren (Germany). Those seminars covered a broad range of topics in analysis and were a reflection of the true spirit of Günter Lumer, who always enjoyed bringing together and working with a wide range of mathematicians and scientists.

Although Günter Lumer's professional focus was on functional analysis, partial differential equations, and evolution equations, he nourished a broad interest for almost all areas of mathematics and for science in general. He published more than one hundred papers and edited many books. Probably his best known result is the celebrated Lumer-Phillips theorem, which gives necessary and sufficient conditions on an operator to generate a strongly continuous semigroup of contractions on a general Banach space. This result, published in the *Pacific Journal of Mathematics* in 1961, is a key contribution to the theory of operator semigroups.

Günter Lumer deeply loved mathematics. He considered his work as the most precious thing he could leave to future generations. He was an independent and original person, never influenced by fashion or convention. He used to say, "If a crowd of a thousand unanimously condemns someone, then he must be innocent. For it is unlikely for a thousand people to honestly agree on the same thing."

With Günter Lumer we miss an inspiring teacher, a mentor and friend of a generation of researchers, and a leader of our professional community. Günter Lumer: a mathematician to be honored.

List of Ph.D. students of Günter Lumer

Charles Widger, *Multiplicative perturbations of generators of semigroups of operators*, U. Washington, 1970

David Neu, *Summability of the linear predictor*, U. Washington, 1972

Luc Paquet, *Sur les équations d'évolution en norme uniforme*, U. Mons, 1978

Roger-Marie Dubois, *Equations d'évolution vectorielles, problèmes mixte et formule de Duhamel*, U. Mons, 1981

Serge Nicaise, *Diffusion sur les espaces ramifiés*, U. Mons, 1986

Maryse Bourlard, *Méthodes d'éléments finis de bord raffinés pour des problèmes aux limites concernant le laplacien et le bilaplacien dans des domaines polygonaux du plan*, U. Mons, 1988

List of publications of Günter Lumer

Wilansky, A. and Lumer, G., Advanced Problems and Solutions: Solutions: 4397, Amer. Math. Monthly 58 (1951), no. 10, 706–708.

Butchart, J.H. and Lumer, G., Advanced Problems and Solutions: Solutions: 4403, Amer. Math. Monthly 59 (1952), no. 2, 115.

- Grossman, G., Newman, D.J., Blumenthal, L.M., Venkataraman, C.S. and Lumer, G., Advanced Problems and Solutions: Problems for Solution: 4488–4492, Amer. Math. Monthly 59 (1952), no. 5, 332–333.
- Lumer, G. and Beesley, E.M., Advanced Problems and Solutions: Solutions: 4492, Amer. Math. Monthly 60 (1953), no. 8, 557.
- Halmos, P.R., Lumer, G. and Schäffer, J.J., Square roots of operators, Proc. Am. Math. Soc. 4, 142–149 (1953).
- Lumer, G., Fine structure and continuity of spectra in Banach algebras, Anais Acad. Brasil. Ci. 26, 229–233 (1954).
- Halmos, P.R. and Lumer, G., Square roots of operators. II, Proc. Am. Math. Soc. 5, 589–595 (1954).
- Lumer, G., Sets with connected spherical section (Portuguese), Soc. Paranaense Mat., Anuário 2, 12–17 (1955).
- Jones, A. and Lumer, G., A note on radical rings (Spanish), Fac. Ing. Agrimensura Montevideo, Publ. Inst. Mat. Estad. 3, 11–15 (1956).
- Lumer, G., Polygons inscriptible in convex curves (Spanish), Rev. Un. Mat. Argentina 17, 97–102 (1956).
- Lumer, G., The range of the exponential function, Fac. Ing. Agrimensura Montevideo, Publ. Inst. Mat. Estad. 3, 53–55 (1957).
- Lumer, G., Commutators in Banach algebras (Spanish) Fac. Ing. Agrimensura Montevideo, Publ. Inst. Mat. Estad. 3, 57–63 (1957).
- Lumer, G. and Rosenblum, M., Linear operator equations, Proc. Am. Math. Soc. 10, 32–41 (1959).
- Lumer, G. and Phillips, R.S., Dissipative operators in a Banach space, Pac. J. Math. 11, 679–698 (1961).
- Lumer, G., Semi-inner-product spaces, Trans. Am. Math. Soc. 100, 29–43 (1961).
- Lumer, G., Isometries of Orlicz spaces, Bull. Am. Math. Soc. 68, 28–30 (1962).
- Lumer, G., Points extrêmes associés: frontières de Silov et Choquet; principe du minimum (French), C.R. Acad. Sci. Paris 256, 858–861 (1963).
- Lumer, G., Points extrêmes associés; frontières de Silov et Choquet: application aux cônes de fonctions semi-continues (French), C.R. Acad. Sci. Paris 256, 1066–1068 (1963).
- Lumer, G., On the isometries of reflexive Orlicz spaces, Ann. Inst. Fourier 13, No. 1, 99–109 (1963).
- Lumer, G., Analytic functions and Dirichlet problem, Bull. Am. Math. Soc. 70, 98–104 (1964).
- Lumer, G., Spectral operators, hermitian operators, and bounded groups, Acta Sci. Math. 25, 75–85 (1964).
- Lumer, G., Remarks on n -th roots of operator, Acta Sci. Math. 25, 72–74 (1964).
- Lumer, G., Herglotz transformation and H^p theory, Bull. Am. Math. Soc. 71, 725–730 (1965).
- Lumer, G., H^∞ and the imbedding of the classical H^p spaces in arbitrary ones, Function Algebras, Proc. Int. Symp. Tulane Univ. 1965, 285–286 (1966).

- Lumer, G., The Herglotz transformation and H^p theory, *Function Algebras*, Proc. Int. Symp. Tulane Univ. 1965, 287–291 (1966).
- Lumer, G., Classes H^∞ et théorème de Phragmen-Lindelöf, pour le disque unité et les surfaces de Riemann hyperboliques (French), *C.R. Acad. Sci. Paris, Sér. A* 262, 1164–1166 (1966).
- Lumer, G., Intégrabilité uniforme dans les algèbres de fonctions, classes H^∞ et classe de Hardy universelle (French), *C.R. Acad. Sci. Paris, Sér. A* 262, 1046–1049 (1966).
- Lumer, G., Un théorème de modification de convergence, valable pour les mesures représentatives arbitraires (French), *C.R. Acad. Sci. Paris, Sér. A* 266, 416–418 (1968).
- Lumer, G., Une théorie des espaces de Hardy abstraits valable pour des algèbres de fonctions arbitraires (French), *C.R. Acad. Sci. Paris, Sér. A* 267, 88–91 (1968).
- Lumer, G., *Algèbres de fonctions et espaces de Hardy* (French), Springer-Verlag, Berlin-Heidelberg-New York, 80 p. (1968).
- Gamelin, T. and Lumer, G., Theory of abstract Hardy spaces and the universal Hardy class, *Adv. Math.* 2, 118–174 (1968).
- Lumer, G., On Wermer's maximality theorem, *Invent. Math.* 8, 236–237 (1969).
- Lumer, G., On some results concerning uniform approximation, Summer Gathering Function Algebras 1969, various Publ. Ser. 9, 63–66 (1969).
- Lumer, G., On some results concerning uniform approximation, *Invent. Math.* 9, 246–248 (1970).
- Lumer, G., Algèbres de fonctions, espaces de Hardy, et fonctions de plusieurs variables complexes, *Algèbres de Fonctions*, Journées Soc. Math. France 1970, 45–46 (1970).
- Lumer, G., Espaces de Hardy en plusieurs variables complexes (French), *C.R. Acad. Sci. Paris, Sér. A* 273, 151–154 (1971).
- Lumer, G., Bounded groups and a theorem of Gelfand, *Rev. Un. Mat. Argentina* 25, 239–245 (1971).
- Gustafson, K. and Lumer, G., Multiplicative perturbation of semigroup generators, *Pac. J. Math.* 41, 731–742 (1972).
- Lumer, G., Normes invariantes et caractérisations des transformées de Fourier des mesures (French), *C.R. Acad. Sci. Paris, Sér. A* 274, 749–751 (1972).
- Lumer, G., États, algèbres quotients et sous-espaces invariants (French), *C.R. Acad. Sci. Paris, Sér. A* 274, 1308–1311 (1972).
- Lumer, G., Quelques aspects de la théorie des algèbres uniformes et des espaces de Hardy (French), *Séminaire d'analyse moderne*. No. 6. Sherbrooke, Québec, Canada, Département de Mathématiques, Université de Sherbrooke, 66 p. (1972).
- Lumer, G., Complex methods, and the estimation of operator norms and spectra from real numerical ranges, *J. Funct. Anal.* 10, 482–495 (1972).
- Lumer, G., Perturbations de générateurs infinitésimaux du type “changement de temps” (French), *Ann. Inst. Fourier* 23, No. 4, 271–279 (1973).
- Lumer, G., Potential-like operators and extensions of Hunt's theorem for σ -compact spaces, *J. Funct. Anal.* 13, 410–416 (1973).
- Lumer, G., Bochner's theorem, states, and the Fourier transforms of measures, *Stud. Math.* 46, 135–140 (1973).

- Lumer, G., Problème de Cauchy pour opérateurs locaux, et "changement de temps" (French), *Ann. Inst. Fourier* 25, No. 3-4, 409-446 (1975).
- Lumer, G., Problème de Cauchy avec valeurs au bord continues (French), *C.R. Acad. Sci. Paris, Sér. A* 281, 805-807 (1975).
- Lumer, G., Problème de Cauchy pour opérateurs locaux (French), *C.R. Acad. Sci. Paris, Sér. A* 281, 763-765 (1975).
- Lumer, G., Images numériques, principe du maximum généralisé, et résolvantes (French), *Séminaire de Théorie du Potentiel Paris 1972-74, Lect. Notes Math.* 518, 107-119 (1976).
- Lumer, G., Problème de Cauchy avec valeurs au bord continues, comportement asymptotique, et applications (French), *Séminaire de Théorie du Potentiel Paris, No. 2, Lect. Notes Math.* 563, 193-201 (1976).
- Lumer, G., Problème de Cauchy et fonctions surharmoniques (French), *Séminaire de Théorie du Potentiel Paris, No. 2, Lect. Notes Math.* 563, 202-218 (1976).
- Lumer, G., Équations d'évolution pour opérateurs locaux non localement fermés (French), *C.R. Acad. Sci. Paris, Sér. A* 284, 1361-1363 (1977).
- Lumer, G. and Paquet, L., Semi-groupes holomorphes et équations d'évolution (French), *C.R. Acad. Sci. Paris, Sér. A* 284, 237-240 (1977).
- Lumer, G., Équations d'évolution en norme uniforme pour opérateurs elliptiques. Régularité des solutions (French), *C.R. Acad. Sci. Paris, Sér. A* 284, 1435-1437 (1977).
- Lumer, G., Équations d'évolution en norme uniforme (conditions nécessaires et suffisantes de résolution et holomorphie) (French), *Sémin. Goulaouic-Schwartz 1976-1977, Équat. dér. part. Anal. fonct., Exposé No. V*, 8 p. (1977).
- Lumer, G., Evolution equations in sup-norm context and in L^2 variational context, *Lin. Räume und Approx., Abh. Tag. Oberwolfach 1977, ISNM* 40, 547-558 (1978).
- Lumer, G., Principe du maximum et équations d'évolution dans L^2 (French), *Séminaire de Théorie du Potentiel Paris, No. 3, Lect. Notes Math.* 681, 143-156 (1978).
- Lumer, G., Approximation des solutions d'équations d'évolution pour opérateurs locaux en général et pour opérateurs elliptiques (French), *C.R. Acad. Sci. Paris, Sér. A* 288, 189-192 (1979).
- Lumer, G., Perturbations additives d'opérateurs locaux (French), *C.R. Acad. Sci. Paris, Sér. A* 288, 107-110 (1979).
- Lumer, G. and Paquet, L., Semi-groupes holomorphes, produit tensoriel de semi-groupes et équations d'évolution (French), *Séminaire de Théorie du Potentiel Paris, No. 4, Lect. Notes Math.* 713, 156-177 (1979).
- Lumer, G., Équations de diffusion sur des réseaux infinis (French), *Sémin. Goulaouic-Schwartz 1979-1980, Équat. dér. part., Exposé No. 18*, 9 p. (1980).
- Lumer, G., Connecting of local operators and evolution equations on networks, Potential theory, *Proc. Colloq., Copenhagen 1979, Lect. Notes Math.* 787, 219-234 (1980).
- Lumer, G., Approximation d'opérateurs locaux et de solutions d'équations d'évolution (French), *Séminaire de Théorie du Potentiel Paris, No. 5, Lect. Notes Math.* 814, 166-185 (1980).
- Lumer, G., Espaces ramifiés, et diffusions sur les réseaux topologiques (French), *C.R. Acad. Sci. Paris, Sér. A* 291, 627-630 (1980).

- Lumer, G., Local operators, regular sets, and evolution equations of diffusion type, Functional analysis and approximation, Proc. Conf., Oberwolfach 1980, ISNM 60, 51–71 (1981).
- Lumer, G., Local dissipativeness and closure of local operators, Toeplitz centennial, Toeplitz Mem. Conf., Tel Aviv 1981, Operator Theory, Adv. Appl. 4, 415–426 (1982).
- Lumer, G., Redheffer, R. and Walter, W., Comportement des solutions d'inéquations différentielles dégénérées du second ordre, et applications aux diffusions (French), C.R. Acad. Sci. Paris, Sér. I 294, 617–620 (1982).
- Lumer, G., Équations de diffusion générales sur des réseaux infinis (French), Séminaire de Théorie du Potentiel Paris, No. 7, Lect. Notes Math. 1061, 230–243 (1984).
- Lumer, G., An exponential formula of Hille-Yosida type for propagators, Approximation theory and functional analysis, Anniv. Vol., Proc. Conf., Oberwolfach 1983, ISNM 65, 527–542 (1984).
- Dubois, R.M. and Lumer, G., Formule de Duhamel abstraite (French), Arch. Math. 43, 49–56 (1984).
- Lumer, G., Équations d'évolution, semigroupes en espace-temps et perturbations (French), C.R. Acad. Sci. Paris, Sér. I 300, 169–172 (1985).
- Lumer, G., Opérateurs d'évolution, comparaison de solutions, perturbations et approximations (French), C.R. Acad. Sci. Paris, Sér. I 301, 351–354 (1985).
- Lumer, G., Local operators, space-time methods, and evolution equations of diffusion type, Aspects of positivity in functional analysis, Proc. Conf. in the occasion of H.H. Schaefer's Birthday, Tübingen 1985, North-Holland Math. Stud. 122, 157–168 (1986).
- Lumer, G., Principes du maximum paraboliques pour des domaines (x, t) non-cylindriques (French), Séminaire de Théorie du Potentiel Paris, No. 8, Lect. Notes Math. 1235, 105–113 (1987).
- Lumer, G., Perturbations “homotopiques”. Perturbations singulières et non singulières de semi-groupes d'opérateurs et de familles résolventes (French), C.R. Acad. Sci. Paris, Sér. I 306, No. 13, 551–556 (1988).
- Lumer, G., Redheffer, R. and Walter, W., Estimates for solutions of degenerate second-order differential equations and inequalities with applications to diffusion, Nonlinear Anal., Theory Methods Appl. 12, No. 10, 1105–1121 (1988).
- Lumer, G., Applications de l'analyse non standard à l'approximation des semi-groupes d'opérateurs et aux équations d'évolution (French), C.R. Acad. Sci. Paris, Sér. I 309, No. 3, 167–172 (1989).
- Lumer, G., Singular perturbation and operators of finite local type, Semigroup theory and applications, Proc. Conf., Trieste/Italy 1987, Lect. Notes Pure Appl. Math. 116, 291–302 (1989).
- Lumer, G., Équations de diffusion dans des domaines (x, t) non-cylindriques et semi-groupes “espace-temps” (French), Séminaire de Théorie du Potentiel Paris, Lect. Notes Math. 1393, 161–180 (1989).
- Lumer, G., Homotopy-like perturbation: General results and applications, Arch. Math. 52, No. 6, 551–561 (1989).

- Lumer, G., New singular multiplicative perturbation results via homotopy-like perturbation, *Arch. Math.* 53, No. 1, 52–60 (1989).
- Lumer, G., Solutions généralisées et semi-groupes intégrés (French), *C.R. Acad. Sci. Paris, Sér. I* 310, No. 7, 577–582 (1990).
- Lumer, G., Applications des solutions généralisées et semi-groupes intégrés à des problèmes d'évolution (French), *C.R. Acad. Sci. Paris, Sér. I* 311, No. 13, 873–878 (1990).
- Lumer, G., Problèmes dissipatifs et “analytiques” mal posés: Solutions et théorie asymptotique (French. Abridged English version), *C.R. Acad. Sci. Paris, Sér. I* 312, No. 11, 831–836 (1991).
- Lumer, G., Generalized evolution operators and (generalized) C -semigroups, *Semigroup theory and evolution equations*, Proc. 2nd Int. Conf., Delft/Neth. 1989, *Lect. Notes Pure Appl. Math.* 135, Marcel Dekker, 337–345 (1991).
- Lumer, G., Examples and results concerning the behavior of generalized solutions, integrated semigroups, and dissipative evolution problems, *Semigroup theory and evolution equations*, Proc. 2nd Int. Conf., Delft/Neth. 1989, *Lect. Notes Pure Appl. Math.* 135, Marcel Dekker, 347–356 (1991).
- Lumer, G., Semi-groupes irréguliers et semi-groupes intégrés: Application à l'identification de semi-groupes irréguliers analytiques et résultats de génération (French. Abridged English version), *C.R. Acad. Sci. Paris, Sér. I* 314, No. 13, 1033–1038 (1992).
- Lumer, G., Problèmes d'évolution avec chocs (changements brusques de conditions au bord) et valeurs au bord variables entre chocs consécutifs (French. Abridged English version), *C.R. Acad. Sci. Paris, Sér. I* 316, No. 1, 41–46 (1993).
- Lumer, G., Evolution equations. Solutions for irregular evolution problems via generalized solutions and generalized initial values. Applications to periodic shocks models, *Ann. Univ. Sarav., Ser. Math.* 5, No. 1, 102 p. (1994).
- Cioranescu, I. and Lumer, G., Problèmes d'évolution régularisés par un noyau général $K(t)$. Formule de Duhamel, prolongements, théorèmes de génération (French. Abridged English version), *C.R. Acad. Sci. Paris, Sér. I* 319, No. 12, 1273–1278 (1994).
- Lumer, G., Models for diffusion-type phenomena with abrupt changes in boundary conditions in Banach space and classical context. Asymptotics under periodic shocks, in Clément, Ph. et al. (eds.), *Evolution equations, control theory, and biomathematics*, *Lect. Notes Pure Appl. Math.* 155, Marcel Dekker, Basel, 337–351 (1993).
- Lumer, G., On uniqueness and regularity in models for diffusion-type phenomena with shocks, in Clément, Ph. et al. (eds.), *Evolution equations, control theory, and biomathematics*, *Lect. Notes Pure Appl. Math.* 155, Marcel Dekker, Basel, 353–359 (1993).
- Lumer, G., Singular problems, generalized solutions, and stability properties, in Lumer, G. et al. (eds.), *Partial differential equations. Models in physics and biology*, *Math. Res.* 82, Akademie Verlag, Berlin, 204–216 (1994).
- Cioranescu, I. and Lumer, G., On $K(t)$ -convoluted semigroups, in McBride, A.C. et al. (eds.), *Recent developments in evolution equations* (Proceedings of a meeting held

- at the University of Strathclyde, UK, 25–29 July, 1994), Pitman Res. Notes Math. Ser. 324, Longman Scientific & Technical, Harlow, 86–93 (1995).
- Fong, C.K., Lumer, G., Nordgren, E., Radjavi, H. and Rosenthal, P., Local polynomials are polynomials, *Stud. Math.* 115, No. 2, 105–107 (1995).
- Lumer, G., Transitions singulières gouvernées par des équations de type parabolique (French. Abridged English version), *C.R. Acad. Sci. Paris, Sér. I* 322, No. 8, 735–740 (1996).
- Lumer, G., Singular transitions and interactions governed by equations of parabolic type, in Demuth, M. et al. (eds.), *Differential equations, asymptotic analysis, and mathematical physics* (Papers associated with the international conference on partial differential equations, Potsdam, Germany, June 29–July 2, 1996), *Math. Res.* 100, Akademie Verlag, Berlin, 192–217 (1997).
- Lumer, G., Singular evolution problems, regularization, and applications to physics, engineering, and biology, in Janas, J. et al. (eds.), *Linear operators, Proceedings of the semester organized at the Stefan Banach International Mathematical Center, Warsaw, Poland, February 7–May 15, 1994*, Banach Cent. Publ. 38, Polish Academy of Sciences, Inst. of Mathematics, Warsaw, 205–216 (1997).
- Lumer, G. and Neubrander, F., Signaux non-détectables en dimension N dans des systèmes gouvernés par des équations de type parabolique (French. Abridged English version), *C.R. Acad. Sci. Paris, Sér. I, Math.* 325, No. 7, 731–736 (1997).
- Lumer, G., Singular interaction problems of parabolic type with distribution and hyperfunction data, in Demuth, M. et al. (eds.), *Evolution equations, Feshbach resonances, singular Hodge theory.*, *Math. Top.* 16, Wiley-VCH, Berlin, 11–36 (1999).
- Lumer, G. and Neubrander, F., Asymptotic Laplace transforms and evolution equations, in Demuth, M. et al. (eds.), *Evolution equations, Feshbach resonances, singular Hodge theory.*, *Math. Top.* 16, Wiley-VCH, Berlin, 37–57 (1999).
- Lumer, G. and Schnaubelt, R., Local operator methods and time dependent parabolic equations on non-cylindrical domains, in Demuth, M. et al. (eds.), *Evolution equations, Feshbach resonances, singular Hodge theory.*, *Math. Top.* 16, Wiley-VCH, Berlin, 58–130 (1999).
- Lumer, G., An introduction to hyperfunctions and δ -expansions, in Antoniou, I. et al. (eds.), *Generalized functions, operator theory, and dynamical systems*, *Res. Notes Math.* 399, Chapman & Hall/CRC, Boca Raton, 1–25 (1999).
- Bäumer, B., Lumer, G. and Neubrander, F., Convolution kernels and generalized functions, in Antoniou, I. et al. (eds.), *Generalized functions, operator theory, and dynamical systems*, *Res. Notes Math.* 399, Chapman & Hall/CRC, Boca Raton, 68–78 (1999).
- Lumer, G., Interaction problems with distributions and hyperfunctions data, in Antoniou, I. et al. (eds.), *Generalized functions, operator theory, and dynamical systems*, *Res. Notes Math.* 399, Chapman & Hall/CRC, Boca Raton, 299–307 (1999).
- Lumer, G. and Neubrander, F., The asymptotic Laplace transform: New results and relation to Komatsu's Laplace transform of hyperfunctions, in Ali Mehmeti, F. et al. (eds.), *Partial differential equations on multistructures*, *Proceedings of the conference, Luminy, France, Lect. Notes Pure Appl. Math.* 219, Marcel Dekker, New York, 147–162 (2001).

- Lumer, G., Blow up and hovering in parabolic systems with singular interactions: Can we “see” a hyperfunction?, in Lumer, G. et al. (eds.), *Evolution equations and their applications in physical and life sciences*, Lect. Notes Pure Appl. Math. 215, Marcel Dekker, New York, 387–393 (2001).
- Lumer, G. and Schnaubelt, R., Time-dependent parabolic problems on non-cylindrical domains with inhomogeneous boundary conditions, *J. Evol. Equ.* 1, No. 3, 291–309 (2001).
- Lumer, G., A general “isotropic” Paley-Wiener theorem and some of its applications, in Iannelli, M. et al. (eds.), *Evolution equations: applications to physics, industry, life sciences and economics*, Prog. Nonlinear Differ. Equ. Appl. 55, Birkhäuser, Basel, 323–332 (2003).

List of books of Günter Lumer

- Clément, Ph. and Lumer, G., *Evolution equations, control theory, and biomathematics*, Proceedings of the 3rd international workshop-conference held at the Han-sur-Lesse Conference Center of the Belgian Ministry of Education, Lecture Notes in Pure and Applied Mathematics 155, Marcel Dekker, Basel, 580 p. (1993).
- Lumer, G., Nicaise, S. and Schulze, B.-W., *Partial differential equations. Models in physics and biology*, Contributions to the conference held in Han-sur-Lesse (Belgium) in December 1993, Mathematical Research 82, Akademie Verlag, Berlin, 421 p. (1994).
- Antoniou, I. and Lumer, G., *Generalized functions, operator theory, and dynamical systems*, Research Notes in Mathematics 399, Boca Raton, FL, Chapman & Hall/CRC 378 p. (1999).
- Lumer, G. and Weis, L., *Evolution equations and their applications in physical and life sciences*, Proceeding of the Bad Herrenalb (Karlsruhe) conference, Germany, 1999, Lecture Notes in Pure and Applied Mathematics 215, Marcel Dekker, New York, 511 (2001).
- Iannelli, M. and Lumer, G., *Evolution equations: applications to physics, industry, life sciences and economics*, Proceedings of the 7th international conference on evolution equations and their applications, EVEQ2000 conference, Levico Terme, Italy, October 30–November 4, 2000, Progress in Nonlinear Differential Equations and their Applications 55, Birkhäuser, Basel, 423 p. (2003).

In Remembrance of Günter Lumer

Heinz König

Günter Lumer was a close friend of mine for several decades. We had the same age: our dates of birth were but 13 days apart. We met for the first time in the fall of 1962 at a functional analysis conference in Oberwolfach. The year before Günter had published two of his most important papers: the common paper with Ralph PHILLIPS on dissipative operators and the paper on semi-inner products.

The subsequent years were the grand period in the development of the functional analytic theory of abstract analytic functions, known under the key words of uniform algebras and Hardy spaces. We were both deeply involved, with quite often different methods but close results. Günter obtained fundamental breakthroughs in two situations: The first time in Bulletin Amer. Math. Soc. 70(1964), where he was able to develop the abstract counterpart of the classical unit disk situation on an arbitrary uniform algebra and for an individual multiplicative linear functional, under the basic assumption that the functional in question has a unique representing measure. Before that one needed global assumptions on the algebra like to be Dirichlet or logmodular. After his work then 1965 Kenneth HOFFMAN-Hugo ROSSI and myself independently obtained the final abstract version of the classical unit disk situation in terms of a fixed so-called Szegő measure for an individual multiplicative linear functional.

The second breakthrough was in his 1968 Lecture Notes, this time for an arbitrary multiplicative linear functional on any uniform algebra. Günter defined its universal Hardy class and was able to transfer the classical concepts and results to an amazing extent, in particular to establish an abstract conjugation operation via extension of the classical Kolmogorov estimations. He then left the field in the early seventies. I myself returned to it in a common frame with the extended concept of Daniell-Stone integration due to Michael LEINERT 1982, which produced a definitive theory around 1990. But it is clear that to an essential extent the basic contributions are due to Günter Lumer in the sixties.

In all these years we had close contacts. During the academic year 1967/68 Günter stayed at Strasbourg University, thus close to my home University Saarbrücken. In the summer term 1967 he gave a series of lectures in Saarbrücken, and in the winter term 1967/68, which I spent at Caltech in Pasadena, a little

bus supplied by our University brought my students to his lectures in Strasbourg every week. In the academic year 1969/70 Günter Lumer together with Irving GLICKSBERG organized a Research Seminar on function algebras at their home University, the University of Washington in Seattle. I had the good fortune to participate for three months on his invitation.

After his move to Belgium in 1973/74 Günter was a regular visitor to Saarbrücken, both private and for a further series of lectures and several colloquium talks. He wrote a comprehensive survey article on evolution equations for our ANNALES UNIVERSITATIS SARAVIENSIS and published several papers in the ARCHIV DER MATHEMATIK of which I had been the editor for abstract analysis. Our relations became even closer because of the sequence of the NORTH-WEST EUROPEAN ANALYSIS SEMINARS 1992–1997, of which Günter was the unique creator and driving force. We were common chairmen of the second seminar 1993 at Schloss Dagstuhl in the Saar State, which is the Informatics counterpart of the Oberwolfach Institute. Thus we two are in the tiny group of “outside” mathematicians who have ever been chairpersons of conferences at Schloss Dagstuhl. Unfortunately, in 1997 a serious hip joint operation forced Günter to discontinue the beautiful enterprise. There was no successor.

For me the first of the seminars 1992 in Saint-Amand-les-Eaux near Lille was a moving event: Near its end I fell into heart trouble, and my doctor said on the telephone that I should come to his hospital right away but must not drive a car. What then happened was that Günter asked Luc PAQUET to place his own car next to his apartment in Brussels, and took the steering-wheel of my car (which was new at the time) to drive us for at least 400 kilometers to Saarbrücken. We arrived late at night, and my wife said later that I looked radiant with health but Günter grey with exhaustion. This was the deepest evidence of friendship which I ever experienced in my life.

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