

## Derivations of Locally Convex $*$ -Algebras

M. FRAGOULOUPOULOU, M. WEIGT, I. ZARAKAS

*Department of Mathematics, University of Athens, Panepistimiopolis,  
Athens 15784, Greece, fragoulop@math.uoa.gr*

*Department of Mathematics and Applied Mathematics,  
Nelson Mandela Metropolitan University, Summerstrand Campus South,  
Port Elizabeth, 6031, South Africa, weigt.martin@gmail.com*

*Department of Mathematics, University of Athens, Panepistimiopolis,  
Athens 15784, Greece, gzarak@math.uoa.gr*

Presented by Jesús M. F. Castillo

Received March 20, 2011

*Abstract:* This is a survey account on some old and recent results on derivations from a locally convex ( $*$ -) algebra  $A[\tau]$  in a locally convex  $A$ -bimodule. Essential differences with known results in the normed setting will be pointed out and natural questions will be put.

*Key words:* Locally convex algebra, pro- $C^*$ -algebra,  $GB^*$ -algebra, locally convex bimodule, derivation, inner derivation.

AMS Subject Class. (2010): 46M05, 46L06, 47L60.

*This paper is dedicated to the memory of Susanne Dierolf*

### REFERENCES

- [1] S. ALBEVERIO, SH.A. AYUPOV, K.K. KUDAYBERGENOV, Derivations on the algebra of measurable operators affiliated with a type I von Neumann algebra, arXiv: math.OA/0703171, 7 August 2008.
- [2] S. ALBEVERIO, SH.A. AYUPOV, K.K. KUDAYBERGENOV, Structure of derivations on various algebras of measurable operators for type I von Neumann algebras, *J. Funct. Anal.* **256** (9) (2009), 2917–2943.
- [3] G.R. ALLAN, On a class of locally convex algebras, *Proc. London Math. Soc.* (3) **17** (1967), 91–114.
- [4] J.-P. ANTOINE, A. INOUE, C. TRAPANI, “Partial  $*$ -Algebras and their Operator Realizations”, Mathematics and its Applications, 553, Kluwer Academic Publ., Dordrecht, 2002.
- [5] J.-P. ANTOINE, A. INOUE, C. TRAPANI, Spatiality of  $*$ -derivations of partial  $O^*$ -algebras, *J. Math. Phys.* **36** (7) (1995), 3743–3758.
- [6] J.-P. ANTOINE, A. INOUE, C. TRAPANI,  $O^*$ -dynamical systems and  $*$ -derivations of unbounded operator algebras, *Math. Nachr.* **204** (1999), 5–28.
- [7] SH.A. AYUPOV, Derivations on unbounded operator algebras, in “Abstracts of the International Conference on Operator Algebras and Quantum Probability”, Tashkent, September 7–19, 2005, 38–42.

- [8] F. BAGARELLO, M. FRAGOULOUPOULOU, A. INOUE, C. TRAPANI, Structure of locally convex quasi- $C^*$ -algebras, *J. Math. Soc. Japan* **60** (2) (2008), 511–549.
- [9] F. BAGARELLO, A. INOUE, C. TRAPANI, Derivations of quasi  $*$ -algebras, *Int. J. Math. Math. Sci.* **21-24** (2004), 1077–1096.
- [10] F. BAGARELLO, A. INOUE, C. TRAPANI, Exponentiating derivations of quasi  $*$ -algebras: possible approaches and applications, *Int. J. Math. Math. Sci.* **17** (2005), 2805–2820.
- [11] R. BECKER, Derivations on LMC\*-Algebras, *Math. Nachr.* **155** (1992), 141–149.
- [12] A.F. BER, V.I. CHILIN, F.A. SUKOCHEV, Non-trivial derivations in commutative regular algebras, *Extracta Math.* **21** (2) (2006), 107–147.
- [13] A.F. BER, B. DE PAGTER, F.A. SUKOCHEV, Derivations in algebras of operator-valued functions, submitted manuscript, 2008.
- [14] A.F. BER, F.A. SUKOCHEV, Derivations on algebras of measurable operators, Manuscript presented at the international conference "Operator spaces, non-commutative  $L^p$  spaces and applications", 25-29 June 2007, Marseilles, France.
- [15] A. BÖHM, "Quantum Mechanics", Texts and Monographs in Physics, Springer-Verlag, New York, 1979.
- [16] F.F. BONSALL, J. DUNCAN, "Complete Normed Algebras", Springer-Verlag, New York-Heidelberg, 1973.
- [17] O. BRATTELI, D.W. ROBINSON, "Operator Algebras and Quantum Statistical Mechanics, Vol. I", Springer-Verlag, New York-Heidelberg, 1979.
- [18] O. BRATTELI, "Derivations, Dissipations and Group Actions on  $C^*$ -Algebras", Lecture Notes in Mathematics, 1229, Springer-Verlag, Berlin, 1986.
- [19] C. BRÖDEL, G. LASSNER, Derivationen auf gewissen Op\*-algebren, *Math. Nachr.* **67** (1975), 53–58.
- [20] R.L. CARPENTER, Continuity of derivations in  $F$ -algebras, *Amer. J. Math.* **93** (1971), 500–502.
- [21] H.G. DALES, "Banach Algebras and Automatic Continuity", London Mathematical Society Monographs, New Series, 24, The Clarendon Press, Oxford University Press, New York, 2000.
- [22] P.G. DIXON, Generalized  $B^*$ -algebras, *Proc. London Math. Soc.* (3) **21** (1970), 693–715.
- [23] M. FRAGOULOUPOULOU, On locally  $W^*$ -algebras, *Yokohama Math. J.* **34** (1-2) (1986), 35–51.
- [24] M. FRAGOULOUPOULOU, "Topological Algebras with Involution", North-Holland Mathematics Studies, 200, Elsevier Science B.V., Amsterdam, 2005.
- [25] M. FRAGOULOUPOULOU, A. INOUE, K.-D. KÜRSTEN, Old and new results on Allan's  $GB^*$ -algebras, *Banach Center Publ.* **91** (2010), 169–178.
- [26] H. GOLDMANN, "Uniform Fréchet Algebras", North-Holland Mathematics Studies, 162, North-Holland, Amsterdam, 1990.
- [27] R. HAAG, D. KASTLER, An algebraic approach to quantum field theory, *J. Math. Phys.* **5** (1964), 848–861.

- [28] A.YA. HELEMSKII, “The Homology of Banach and Topological Algebras”, Kluwer Academic Publishers Group, Dordrecht, 1989.
- [29] A.YA. HELEMSKII, “Banach and Locally Convex Algebras”, Oxford Science Publications, Oxford University Press, New York, 1993.
- [30] A. INOUE, “Tomita-Takesaki Theory in Algebras of Unbounded Operators”, Lecture Notes in Mathematics, 1699, Springer-Verlag, Berlin, 1998.
- [31] A. INOUE, S. OTA, Derivations on algebras of unbounded operators, *Trans. Amer. Math. Soc.* **261** (2) (1980), 567–577.
- [32] A. INOUE, S. OTA, J. TOMIYAMA, Derivations of operator algebras into spaces of unbounded operators, *Pacific J. Math.* **96** (2) (1981), 389–404.
- [33] B.E. JOHNSON, Continuity of derivations on commutative algebras, *Amer. J. Math.* **91** (1969), 1–10.
- [34] B.E. JOHNSON, “Cohomology in Banach Algebras”, Mem. Amer. Math. Soc., No. 127, American Mathematical Society, Providence, R.I., 1972.
- [35] B.E. JOHNSON, A.M. SINCLAIR, Continuity of derivations and a problem of Kaplansky, *Amer. J. Math.* **90** (1968), 1067–1073.
- [36] I. KAPLANSKY, Some Aspects of Analysis and Probability, pp. 1–34, Surveys in Applied Mathematics. Vol. 4, John Wiley & Sons, Inc., New York, 1958.
- [37] G. LASSNER, Topological algebras of operators, *Rep. Math. Phys.* **3** (4) (1972), 279–293.
- [38] G. LASSNER, Topological algebras and their applications in quantum statistics, *Wiss. Z. Karl-Marx-Univ. Leipzig, Math.-Natur. Reihe* **30** (6) (1981), 572–595.
- [39] G. LASSNER, Algebras of unbounded operators and quantum dynamics, Mathematical physics, VII (Boulder, CO, 1983), *Physica* **A 124** (1-3) (1984), 471–479.
- [40] A. MALLIOS, “Topological Algebras. Selected Topics”, North-Holland Mathematics Studies, 124, North-Holland, Amsterdam, 1986.
- [41] G.J. MURPHY, “ $C^*$ -Algebras and Operator Theory”, Academic Press, Boston, 1990.
- [42] G.K. PEDERSEN, “ $C^*$ -algebras and their Automorphism Groups”, London Mathematical Society Monographs, 14, Academic Press, London, 1979.
- [43] N.C. PHILLIPS, Inner derivations on  $\sigma$ - $C^*$ -algebras, *Math. Nachr.* **176** (1995), 243–247.
- [44] C.P. PODARA, “Homological Properties of Fréchet and Locally  $C^*$ -Algebras” (in Greek), PhD Thesis, University of Athens, Greece, 2009.
- [45] C.J. READ, Derivations with large separating subspace, *Proc. Amer. Math. Soc.* **130** (12) (2002), 3671–3677.
- [46] J.R. RINGROSE, Automatic continuity of derivations of operator algebras, *J. London Math. Soc.* **5** (2) (1972), 432–438.
- [47] S. SAKAI,  $C^*$ -Algebras and  $W^*$ -Algebras, Ergebnisse der Mathematik und ihrer Grenzgebiete, Band 60, Springer-Verlag, Berlin, 1971.
- [48] S. SAKAI, “Operator Algebras in Dynamical Systems, The theory of unbounded derivations in  $C^*$ -algebras”, Encyclopedia of Mathematics and its Applications, 41, Cambridge University Press, 1991.

- [49] K. SCHMÜDGEN, “Unbounded Operator Algebras and Representation Theory”, Birkhäuser Verlag, Basel, 1990.
- [50] G.E. ŠILOV, On a property of rings of functions, *Dokl. Akad. Nauk. SSSR (N.S.)* **58** (1947), 985–988.
- [51] A.M. SINCLAIR, “Automatic Continuity of Linear Operators”, London Mathematical Society Lecture Note Series, 21, Cambridge University Press, Cambridge-New York-Melbourne, 1976.
- [52] M.P. THOMAS, The image of a derivation is contained in the radical, *Ann. Math. (2)* **128** (3) (1988), 435–460.
- [53] J. TOMIYAMA, “The Theory of Closed Derivations in the Algebra of Continuous Functions on the Unit Interval”, Lecture Notes, Inst. Math., National Tsing Hua University, 1983.
- [54] C. TRAPANI, States and derivations on quasi \*-algebras, *J. Math. Phys.* **29** (8) (1988), 1885–1890.
- [55] M. WEIGT, Derivations of  $\tau$ -measurable operators, in “Operator Algebras, Operator Theory and Applications”, Oper. Theory Adv. Appl., 195, Birkhäuser-Verlag, Basel, 2009, 273–286.
- [56] M. WEIGT, I. ZARAKAS, Derivations of pro- $C^*$ -algebras into complete locally convex bimodules, preprint.
- [57] H. WIELANDT, Über die Unbeschränktheit der Operatoren der Quantenmechanik, *Math. Ann.* **121** (1949), 21.
- [58] I. ZARAKAS, Hilbert pro- $C^*$ -bimodules and applications, submitted.