

ALMOST EVERYWHERE STRONG SUMMABILITY OF CUBIC PARTIAL SUMS OF D-DIMENSIONAL WALSH-FOURIER SERIES

USHANGI GOGINAVA

Abstract. In this paper we study the a. e. strong summability of the cubic partial sums of the d-dimensional Walsh-Fourier series of the functions belonging to $L(\log^+ L)^{d-1}$.

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REFERENCES

- [1] N. YU. ANTONOV, *On the convergence almost everywhere of multiple trigonometric Fourier series over cubes* (Russian), *Izv. Ross. Akad. Nauk Ser. Mat.* **68**, 2 (2004), 3–22; translation in *Izv. Math.* **68**, 2 (2004), 223–241.
- [2] M. I. DYACHENKO, *On the (C, α) -summability of multiple trigonometric Fourier series*, *Soobshch. Akad. Grusin* **131**, 2 (1988), 261–263 (Russian).
- [3] L. FEJÉR, *Untersuchungen über Fouriersche Reihen*, *Math. Annalen* **58** (1904), 501–569.
- [4] S. FRIDL AND F. SCHIPP, *Strong summability and Sidon type inequalities*, *Acta Sci. Math. (Szeged)* **60**, 1–2 (1995), 277–289.
- [5] S. FRIDL AND F. SCHIPP, *Strong approximation via Sidon type inequalities*, *J. Approx. Theory* **94** (1998), 263–284.
- [6] O. D. GABISONIA, *On strong summability points for Fourier series*, *Mat. Zametki* **14**, 5 (1973), 615–626.
- [7] G. GÁT, U. GOGINAVA AND G. KARAGULYAN, *Almost everywhere strong summability of Marcinkiewicz means of double Walsh-Fourier series*, *Anal. Math.* **40**, 4 (2014), 243–266.
- [8] G. GÁT, U. GOGINAVA AND G. KARAGULYAN, *On everywhere divergence of the strong Φ -means of Walsh-Fourier series*, *J. Math. Anal. Appl.* **421**, 1 (2015), 206–214.
- [9] U. GOGINAVA, *Uniform convergence of Cesáro means of negative order of double Walsh-Fourier series*, *J. Approx. Theory* **124**, 1 (2003), 96–108.
- [10] U. GOGINAVA, *The weak type inequality for the Walsh system*, *Studia Math.* **185**, 1 (2008), 35–48.
- [11] U. GOGINAVA AND L. GOGOLADZE, *Strong approximation by Marcinkiewicz means of two-dimensional Walsh-Fourier series*, *Constr. Approx.* **35**, 1 (2012), 1–19.
- [12] U. GOGINAVA AND L. GOGOLADZE, *Convergence in measure of strong logarithmic means of double Fourier series*, *Izv. Nats. Akad. Nauk Armenii Mat.* **49**, 3 (2014), 39–49; translation in *J. Contemp. Math. Anal.* **49**, 3 (2014), 109–116.
- [13] U. GOGINAVA, L. GOGOLADZE AND G. KARAGULYAN, *BMO-estimation and almost everywhere exponential summability of quadratic partial sums of double Fourier series*, *Constr. Approx.* **40**, 1 (2014), 105–120.
- [14] B. I. GOLUBOV, A. V. EFIMOV AND V. A. SKVORTSOV, *Series and transformations of Walsh*, Moscow, 1987 (Russian); English translation, Kluwer Academic, Dordrecht, 1991.
- [15] R. GETSADZE, *On the boundedness in measure of sequences of superlinear operators in classes $L\phi(L)$* , *Acta Sci. Math. (Szeged)* **71**, 1–2 (2005), 195–226.
- [16] L. GOGOLADZE, *On the exponential uniform strong summability of multiple trigonometric Fourier series*, *Georgian Math. J.* **16** (2009), 517–532.
- [17] L. GOGOLADZE, *Strong means of Marcinkiewicz type*, (Russian), *Soobshch. Akad. Nauk Gruzin. SSR* **102**, 2 (1981), 293–295.

- [18] V. A. GLUKHOV, *Summation of multiple Fourier series in multiplicative systems*, (Russian), *Mat. Zametki* **39**, 5 (1986), 665–673.
- [19] R. E. EDWARDS, *Fourier series: a Modern Introduction*, vol. 1, Springer-Verlag, New-York, Heidelberg, Berlin 1982.
- [20] G. H. HARDY AND J. E. LITTLEWOOD, *Sur la series de Fourier d'une fonction a carre sommable*, *Comptes Rendus (Paris)* **156** (1913), 1307–1309.
- [21] G. A. KARAGULYAN, *Everywhere divergent Φ -means of Fourier series*, (Russian), *Mat. Zametki* **80**, 1 (2006), 50–59; translation in *Math. Notes* **80**, 1–2 (2006), 47–56.
- [22] S. V. KONYAGIN, *On the divergence of subsequences of partial sums of multiple trigonometric Fourier series*, *Trudy MIAN* **190** (1989), 102–116.
- [23] H. LEBESGUE, *Recherches sur la sommabilite forte des series de Fourier*, *Math. Annalen* **61** (1905), 251–280.
- [24] L. LEINDLER, *Über die Approximation im starken Sinne*, *Acta Math. Acad. Hungar.* **16** (1965), 255–262.
- [25] L. LEINDLER, *On the strong approximation of Fourier series*, *Acta Sci. Math. (Szeged)* **38** (1976), 317–324.
- [26] L. LEINDLER, *Strong approximation and classes of functions*, *Mitteilungen Math. Seminar Giessen* **132** (1978), 29–38.
- [27] L. LEINDLER, *Strong approximation by Fourier series*, *Akadémiiai Kiadó*, Budapest, 1985.
- [28] J. MARCINKIEWICZ, *Sur la sommabilité forte de séries de Fourier*, (French), *J. London Math. Soc.* **14** (1939), 162–168.
- [29] K. I. OSKOLKOV, *Strong summability of Fourier series*, (Russian), *Studies in the theory of functions of several real variables and the approximation of functions*, *Trudy Mat. Inst. Steklov* **172** (1985), 280–290, 355.
- [30] V. A. RODIN, *The space BMO and strong means of Fourier series*, *Anal. Math.* **16**, 4 (1990), 291–302.
- [31] V. A. RODIN, *BMO-strong means of Fourier series*, *Funct. anal. Appl.* **23** (1989), 73–74 (Russian).
- [32] V. A. RODIN, *The space BMO and strong means of Fourier-Walsh series* (Russian), *Mat. Sb.* **182**, 10 (1991), 1463–1478; translation in *Math. USSR-Sb* **74**, 1 (1993), 203–218.
- [33] F. SCHIPP, *On the strong summability of Walsh series*, *Publ. Math. Debrecen* **52**, 3–4 (1998), 611–633.
- [34] F. SCHIPP, *Über die starke Summation von Walsh-Fourier Reihen*, *Acta Sci. Math (Szeged)* **30** (1969), 77–87.
- [35] F. SCHIPP, *On strong approximation of Walsh-Fourier series*, *MTA III. Oszt. Kozl.* **19**, (1969), 101–111 (Hungarian).
- [36] F. SCHIPP AND N. X. KY, *On strong summability of polynomial expansions*, *Anal. Math.* **12** (1986), 115–128.
- [37] F. SCHIPP, W. WADE, P. SIMON AND P. PÁL, *Walsh Series, an Introduction to Dyadic Harmonic Analysis*, Adam Hilger, Bristol, New York, 1990.
- [38] P. SJÖLIN, *Convergence almost everywhere of certain singular integrals and multiple Fourier series*, *Ark. Mat.* **9**, (1971), 65–90.
- [39] V. TOTIK, *On the strong approximation of Fourier series*, *Acta Math. Sci. Hungar.* **35** (1980), 151–172.
- [40] V. TOTIK, *On the generalization of Fejér's summation theorem*, *Functions, Series, Operators*, *Coll. Math. Soc. J. Bolyai (Budapest) Hungary*, **35**, North Holland, Amsterdam-Oxford-New-York, 1980, 1195–1199.
- [41] V. TOTIK, *Notes on Fourier series: Strong approximation*, *J. Approx. Theory* **43** (1985), 105–111.
- [42] F. WEISZ, *Convergence of double Walsh-Fourier series and Hardy spaces*, *Approx. Theory & its Appl.* **17**, 2 (2001), 32–44.
- [43] F. WEISZ, *Summability of multi-dimensional Fourier series and Hardy space*, *Kluwer Academic*, Dordrecht, 2002.
- [44] F. WEISZ, *Strong summability of more-dimensional Ciesielski-Fourier series*, *East J. Approx.* **10**, 3 (2004), 333–354.
- [45] F. WEISZ, *Strong Marcinkiewicz summability of multi-dimensional Fourier series*, *Ann. Univ. Sci. Budapest. Sect. Comput.* **29** (2008), 297–317.
- [46] F. WEISZ, *Lebesgue points of double Fourier series and strong summability*, *J. Math. Anal. Appl.* **432**, 1 (2015), 441–462.

- [47] L. V. ZHIZHIASHVILI, *Generalization of a theorem of Marcinkiewicz*, *Izvest.AN USSR, ser. matem.* **32** (1968), 1112–1122 (Russian).
- [48] A. ZYGMUND, *Trigonometric series*, Cambridge University Press, Cambridge, 1959.