

GENERALIZED INTEGRATION OPERATORS FROM THE BESOV SPACE INTO GENERAL FUNCTION SPACES

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Abstract. The boundedness of the inclusion mapping from the Besov space B_p into a class of the tent type space $\mathcal{T}_s^{p,n}(\mu)$ is studied. As an application, the boundedness, compactness and essential norm of the generalized integral operators $T_g^{n,k}$ and $S_g^{n,0}$ from the Besov space B_p to general function spaces are also investigated.

Mathematics subject classification (2020): 30H20, 47B38.

Keywords and phrases: Besov space, generalized integration operator, tent space, Carleson measure.

REFERENCES

- [1] A. ALEMAN AND J. CIMA, *An integral operator on H^p and Hardy's inequality*, J. Anal. Math. **85** (2001), 157–176.
- [2] A. ALEMAN AND A. SISKAKIS, *An integral operator on H^p* , Complex Variables Theory Appl. **28** (1995), 149–158.
- [3] A. ALEMAN AND A. SISKAKIS, *Integration operators on Bergman spaces*, Indiana Univ. Math. J. **46** (1997), 337–356.
- [4] K. ATTELE, *Interpolating sequences for the derivatives of Bloch functions*, Glasgow Math. J. **34** (1992), 35–41.
- [5] K. AVETISYAN AND S. STEVIĆ, *Extended Cesàro operators between different Hardy spaces*, Appl. Math. Comput. **207** (2009), 346–350.
- [6] N. CHALMOUKIS, *Generalized integration operators on Hardy spaces*, Proc. Amer. Math. Soc. **148** (2020), 3325–3337.
- [7] F. COLONNA AND M. TJANI, *Operator norms and essential norms of weighted composition operators between Banach spaces of analytic functions*, J. Math. Anal. Appl. **434** (2016), 93–124.
- [8] J. DU, S. LI AND D. QU, *The generalized Volterra integral operator and Toeplitz operator on weighted Bergman spaces*, Mediterr. J. Math. **19** (2022), Paper No. 263, 32 pp.
- [9] P. GALANOPoulos, D. GIRELA AND J. PELÁEZ, *Multipliers and integration operators on Dirichlet spaces*, Trans. Amer. Math. Soc. **363** (2011), 1855–1886.
- [10] J. GARNETT, *Bounded Analytic Functions*, Academic Press, New York, 1981.
- [11] D. GIRELA AND J. PELÁEZ, *Carleson measures, multipliers and integration operators for spaces of Dirichlet type*, J. Funct. Anal. **241** (2006), 334–358.
- [12] P. LI, J. LIU AND Z. LOU, *Integral operators on analytic Morrey spaces*, Sci. China Math. **57** (2014), 1961–1974.
- [13] S. LI, *Volterra composition operators between weighted Bergman spaces and Bloch type spaces*, J. Korean Math. Soc. **45** (2008), 229–248.
- [14] S. LI, J. LIU AND C. YUAN, *Embedding theorems for Dirichlet type spaces*, Canad. Math. Bull. **63** (2020), 106–117.
- [15] S. LI AND S. STEVIĆ, *Integral type operators from mixed-norm spaces to α -Bloch spaces*, Integral Transforms Spec. Funct. **18** (2007), 485–493.
- [16] S. LI AND S. STEVIĆ, *Compactness of Riemann-Stieltjes operators between $F(p,q,s)$ and α -Bloch spaces*, Publ. Math. Debrecen **72** (2008), 111–128.
- [17] S. LI AND S. STEVIĆ, *Riemann-Stieltjes operators between different weighted Bergman spaces*, Bull. Belg. Math. Soc. Simon Stevin **15** (2008), 677–686.

- [18] S. LI AND S. STEVIĆ, *Cesàro type operators on some spaces of analytic functions on the unit ball*, Appl. Math. Comput. **208** (2009), 378–388.
- [19] S. LI AND S. STEVIĆ, *Integral-type operators from Bloch-type spaces to Zygmund-type spaces*, Appl. Math. Comput. **215** (2009), 464–473.
- [20] S. LI AND H. WULAN, *Volterra type operators on Q_K spaces*, Taiwanese J. Math. **14** (2010), 195–211.
- [21] X. LIU, S. LI AND R. QIAN, *Volterra type operators and Carleson embedding on Campanato spaces*, J. Nonlinear Var. Anal. **5** (2021), 141–153.
- [22] J. PAU AND R. ZHAO, *Carleson measures, Riemann-Stieltjes and multiplication operators on a general family of function spaces*, Integr. Equ. Oper. Theory **78** (2014), 483–514.
- [23] J. PELÁEZ, F. PÉREZ-GONZÁLEZ AND J. RÄTTYÄ, *Operator theoretic differences between Hardy and Dirichlet-type spaces*, J. Math. Anal. Appl. **418** (2014), 387–402.
- [24] C. POMMERENKE, *Schlichte funktionen und analytische funktionen von beschränkten mittlerer Oszillation*, Comm. Math. Helv. **52** (1977), 591–602.
- [25] R. QIAN AND S. LI, *Volterra type operators on Morrey type spaces*, Math. Inequal. Appl. **18** (2015), 1589–1599.
- [26] R. QIAN AND X. ZHU, *Embedding of Dirichlet type spaces \mathcal{D}_{p-1}^p into tent spaces and Volterra operators*, Canad. Math. Bull. **64** (2021), 697–708.
- [27] R. QIAN AND X. ZHU, *Embedding Hardy spaces H^p into tent spaces and generalized integration operators*, Ann. Polon. Math. **128** (2022), 143–157.
- [28] R. QIAN AND X. ZHU, *Volterra integral operator from weighted Bergman spaces to general function spaces*, Math. Inequal. Appl. **25** (2022), 985–998.
- [29] J. RÄTTYÄ, *n -th derivative characterizations, mean growth of derivatives and $F(p, q, s)$* , Bull. Australian Math. Soc. **68** (2003), 405–421.
- [30] B. SEHBA AND S. STEVIĆ, *On some product-type operators from Hardy-Orlicz and Bergman-Orlicz spaces to weighted-type spaces*, Appl. Math. Comput. **233** (2014), 565–581.
- [31] C. SHEN, Z. LOU AND S. LI, *Embedding of $BMOA_{\log}$ into tent spaces and Volterra integral operators*, Comput. Methods Funct. Theory **20** (2020), 217–234.
- [32] Y. SHI AND S. LI, *Essential norm of integral operators on Morrey type spaces*, Math. Inequal. Appl. **19** (2016), 385–393.
- [33] A. SISKAKIS AND R. ZHAO, *A Volterra type operator on spaces of analytic functions*, Contemp. Math. **232** (1999), 299–311.
- [34] S. STEVIĆ, *Boundedness and compactness of an integral operator on a weighted space on the polydisc*, Indian J. Pure Appl. Math. **37** (2006), 343–355.
- [35] S. STEVIĆ, *Norms of some operators from Bergman spaces to weighted and Bloch-type space*, Util. Math. **76** (2008), 59–64.
- [36] S. STEVIĆ, *Integral-type operators from a mixed norm space to a Bloch-type space on the unit ball*, Siberian Math. J. **50** (2009), 1098–1105.
- [37] S. STEVIĆ, *Products of integral-type operators and composition operators from the mixed norm space to Bloch-type spaces*, Siberian Math. J. **50** (2009), 726–736.
- [38] S. STEVIĆ, *Norm and essential norm of an integral-type operator from the Dirichlet space to the Bloch-type space on the unit ball*, Abstr. Appl. Anal. **2010** (2010), Article ID 134969, 9 pages.
- [39] S. STEVIĆ, *On an integral-type operator from Zygmund-type spaces to mixed-norm spaces on the unit ball*, Abstr. Appl. Anal. **2010** (2010), Article ID 198608, 7 pages.
- [40] S. STEVIĆ, *On some integral-type operators between a general space and Bloch-type spaces*, Appl. Math. Comput. **218** (2011), 2600–2618.
- [41] S. STEVIĆ, *Boundedness and compactness of an integral-type operator from Bloch-type spaces with normal weights to $F(p, q, s)$ space*, Appl. Math. Comput. **218** (2012), 5414–5421.
- [42] S. STEVIĆ, *Essential norm of some extensions of the generalized composition operators between k th weighted-type spaces*, J. Inequal. Appl. **2017** (2017), Article No. 220, 13 pages.
- [43] S. STEVIĆ AND S. UEKI, *Integral-type operators acting between weighted-type spaces on the unit ball*, Appl. Math. Comput. **215** (2009), 2464–2471.
- [44] R. ZHAO, *On a general family of function spaces*, Ann. Acad. Sci. Fenn. Math. Diss. No. **105** (1996), 56 pp.
- [45] R. ZHAO, *New criteria of Carleson measures for Hardy spaces and their applications*, Complex Var. Elliptic Equ. **55** (2010), 633–646.

- [46] K. ZHU, *Operator Theory in Function Spaces*, Second Edition, Math. Surveys and Monographs, **138** (2007).
- [47] X. ZHU, R. QIAN AND N. HU, *Embedding and Volterra integral operators from Dirichlet-Morrey spaces into general function spaces*, Complex Var. Elliptic Equ. **67** (2022), 2303–2317.