

PROPERTIES OF INTEGRAL OPERATORS ON BERGMAN–MORREY SPACES

RUISHEN QIAN* AND ZHONGHUA HE

Abstract. For $0 < q < \infty$ and $0 < \eta < \infty$, the tent space $T_{q,\eta}(\mu)$ consists of all μ -measurable functions f such that

$$\|f\|_{T_{q,\eta}(\mu)}^q := \sup_{I \subseteq \partial \mathbb{D}} \frac{1}{|I|^\eta} \int_{S(I)} |f(z)|^q d\mu(z) < \infty.$$

In this note, we study the boundedness and compactness of the inclusion mapping i from Bergman–Morrey Spaces $\mathcal{A}^{p,\lambda}$ to Tent Spaces $T_{q,\eta}(\mu)$. The boundedness and essential norm of Volterra integral operators from Bergman–Morrey Spaces $\mathcal{A}^{p,\lambda}$ to Bergman–Morrey Spaces $\mathcal{A}^{q,\eta}$ are also investigated in this paper, which generalized the main results in [31]. In the end, we investigated the closed range Volterra integral operators on Bergman–Morrey Spaces $\mathcal{A}^{p,\lambda}$.

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

Keywords and phrases: Volterra integral operator, Bergman–Morrey spaces, essential norm, closed range.

REFERENCES

- [1] Y. ABRAMOVICH AND C. ALIPRANTIS, *An Invitation to Operator Theory*, Graduate Studies in Mathematics, AMS, vol. 50, (2002).
- [2] A. ANDERSON, *Some Closed Range Integral Operators on Spaces of Analytic Functions*, Integr. Equ. Oper. Theory **69** (2011), 87–99.
- [3] A. ALEMAN AND A. SISKAKIS, *An integral operator on H^p* , Complex Var. Theory Appl. **28** (1955), 149–158.
- [4] A. ALEMAN AND A. SISKAKIS, *Integration operators on Bergman spaces*, Indiana Univ. Math. J. **46** (1997), 337–356.
- [5] P. DUREN, *Theory of H^p Spaces*, Academic Press, New York, 1970.
- [6] M. ESSEN, H. WULAN AND J. XIAO, *Several function-theoretic characterizations of Möbius invariant \mathcal{Q}_K spaces*, J. Funct. Anal. **230** (2006), 78–115.
- [7] P. GALANOPOULOS, N. MERCHAN AND A. G. SISKAKIS, *A family of Dirichlet–Morrey spaces*, Complex Var. Ellipt. Equ. **64** (2019), 1686–1702.
- [8] J. GARNETT, *Bounded Analytic Functions*, Academic Press, New York, 1981.
- [9] D. GIRELA, *Analytic functions of bounded mean oscillation*, Complex Function Spaces (Mekrijärvi, 1999), 61–170, Univ. Joensuu Dept. Math. Rep. Ser. **4**, Univ. Joensuu, Joensuu, 2001.
- [10] D. GIRELA AND J. PELÁEZ, *Carleson measures for spaces of Dirichlet type*, Integral Equations Operator Theory **55** (2006), 415–427.
- [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] B. HU AND S. LI, *$\mathcal{N}(p, q, s)$ -type spaces in the unit ball of \mathbb{C}^n (III): Various characterizations*, Publ. Math. Debrecen. **97** (2020), 41–61.
- [13] P. LI, J. LIU AND Z. LOU, *Integral operators on analytic Morrey spaces*, Sci. China Math. **57** (2014), 1961–1974.

- [14] S. LI, J. LIU AND C. YUAN, *Embedding theorems for Dirichlet type spaces*, *Canad. Math. Bull.* **63** (2020), 106–117.
- [15] D. LUECKING, *Inequalities on Bergman spaces*, *Illinois J. Math.* **25** (1981), 1–11.
- [16] C. MORREY, *On the solutions of quasi-linear elliptic partial differential equations*, *Trans. Amer. Math. Soc.* **43** (1938), 126–166.
- [17] K. PANTERIS, *Closed range integral operators on Hardy, BMOA and Besov spaces*, *Complex Var. Ellt. Equ.* **67** (2021), 2011–2029.
- [18] 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.
- [19] C. POMMERENKE, *Schlichte funktionen und analytische funktionen von beschränkten mittlerer Oszillation*, *Comm. Math. Helv.* **52** (1977), 591–602.
- [20] R. QIAN AND S. LI, *Volterra type operators on Morrey type spaces*, *Math. Inequal. Appl.* **18** (2015), 1589–1599.
- [21] R. QIAN AND X. ZHU, *Embedding Hardy spaces H^p into tent spaces and generalized inte*, *Annales Polonici Mathematici.* **128** (2022), 143–157.
- [22] R. QIAN AND X. ZHU, *Integral operators from Morrey type spaces to weighted BMOA spaces*, *Bull. Korean Math. Soc.* **58** (2021), 815–828.
- [23] Y. SHI AND S. LI, *Essential norm of integral operators on Morrey type spaces*, *Math. Inequal. Appl.* **19** (2016), 385–393.
- [24] A. SISKAKIS AND R. ZHAO, *A Volterra type operator on spaces of analytic functions*, (Edwardsville, IL, 1998), *Contemp. Math. American Mathematical Society. Rhode Island.* **232** (1999), 299–311.
- [25] M. TJANI, *Compact Composition Operators on Some Möbius Invariant Banach Spaces*, PhD dissertation, Michigan State University, 1996.
- [26] Z. WU AND C. XIE, *\mathcal{Q}_p spaces and Morrey spaces*, *J. Funct. Anal.* **201** (2003), 282–297.
- [27] H. WULAN AND J. ZHOU, *\mathcal{Q}_K and Morrey type spaces*, *Ann. Acad. Sci. Fenn. Math.* **38** (2013), 193–207.
- [28] J. XIAO, *Holomorphic \mathcal{Q} Classes*, Springer, LNM 1767, Berlin, 2001.
- [29] J. XIAO, *The \mathcal{Q}_p Carleson measure problem*, *Adv. Math.* **217** (2008), 2075–2088.
- [30] J. XIAO AND C. YUAN, *Analytic Campanato spaces and their compositions*, *Indian. Univ. Math. J.* **64** (2015), 1001–1025.
- [31] Y. YANG, J. LIU, *Integral operators on Bergman-Morrey spaces*, *J. Geom. Anal.* **32** (2022), Paper No. 181, 23 p.
- [32] R. ZHAO, *On a general family of function spaces*, *Ann. Acad. Sci. Fenn. Math. Diss.* **105** (1996), 56 pp.
- [33] J. ZHOU AND X. ZHU, *Essential norm of a Volterra-type integral operator from Hardy spaces to some analytic function spaces*, *J. Integral Equations Applications.* **28** (2016), 581–593.
- [34] K. ZHU, *Bloch type spaces of analytic functions*, *Rocky Mountain J. Math.* **23** (1993), 1143–1177.
- [35] K. ZHU, *Operator Theory in Function Spaces*, Mathematical Society, Providence, RI, 2007.
- [36] X. ZHU, L. HU AND D. QU, *Dirichlet-Morrey type spaces and Volterra integral operators*, *Complex Var. Ellt. Equ.* **69** (2024), 301–316.