

REFINEMENTS AND SHARPNESS OF SOME NEW HUYGENS TYPE INEQUALITIES

YUN HUA

Abstract. In the article, some Huygens inequalities involving trigonometric and hyperbolic functions are refined and sharpened.

Mathematics subject classification (2010): Primary 26D05; Secondary 33B10.

Keywords and phrases: Refinement, sharpening, Huygens inequality, Wilker inequality, trigonometric function, hyperbolic function.

REFERENCES

- [1] M. ABRAMOWITZ AND I. A. STEGUN (EDS), *Handbook of Mathematical Functions with Formulas, Graphs, and Mathematical Tables*, National Bureau of Standards, Applied Mathematics Series **55**, 4th printing, with corrections, Washington, 1965.
- [2] G. E. ANDREWS, R. ASKEY, AND R. ROY, *Special Functions*, Encyclopedia of Mathematics and its Applications **71**, Cambridge University Press, Cambridge, 1999.
- [3] H. ALZER AND S.-L. QIU, *Monotonicity theorems and inequalities for complete elliptic integrals*, J. Comput. Appl. Math. **172** (2004), no. 2, 289–312.
- [4] C. MORTICI, *The natural approach of Wilker-Cusa-Huygens inequalities*, Math. Inequal. Appl. **14** (2011), no. 3, 535–541.
- [5] E. NEUMAN, *On Wilker and Huygens type inequalities*, Math. Inequal. Appl. **14** (2011), in press.
- [6] E. NEUMAN AND J. SÁNDOR, *On some inequalities involving trigonometric and hyperbolic functions with emphasis on the Cusa-Huygens, Wilker, and Huygens inequalities*, Math. Inequal. Appl. **13** (2010), no. 4, 715–723.
- [7] J. SÁNDOR AND M. BENCZE, *On Huygens' trigonometric inequality*, RGMIA Res. Rep. Coll. **8** (2005), no. 3, Art. 14.
- [8] J. S. SUMNER, A. A. JAGERS, M. VOWE, AND J. ANGLESIIO, *Inequalities involving trigonometric functions*, Amer. Math. Monthly **98** (1991), no. 3, 264–267.
- [9] J. B. WILKER, *Problem E 3306*, Amer. Math. Monthly **96** (1989), no. 1, 55.
- [10] S.-H. WU AND H. M. SRIVASTAVA, *A further refinement of Wilker's inequality*, Integral Transforms Spec. Funct. **19** (2008), no. 10, 757–765.
- [11] S. PONNUSAMY AND M. VUORINEN, *Asymptotic expansions and inequalities for hypergeometric functions*, Mathematika, **44**(1997), no. 2, 278–301.
- [12] C. DANIELLO, *On Some Inequalities for the Bernoulli Numbers*, Rend. Circ. Mat. Palermo **43**(1994), 329–332.
- [13] H. ALZER, *Sharp bounds for the Bernoulli Numbers*, Arch. Math. **74** (2000), 207–211.
- [14] CHAO-PING CHEN AND JÓZSEF SÁNDOR, *Inequality chains for Wilker, Huygens and Lazarević type inequalities*, RGMIA Research Report Collection, **15**(2012), Article 11, 11 pp.
- [15] WEI-DONG JIANG, QIU-MING LUO AND FENG QI, *Refinements and Sharpening of some Huygens and Wilker type inequalities*, Integral Transforms Spec. Funct. (in press).
- [16] W. SCHARLAU, H. OPOLKA, *from Fermat to Minkowski: Lectures on the Theory of Numbers and Its Historical Development*, Springer-Verlag New York Inc., 1985.
- [17] M. BIERNACKI, J. KRZYŻ, *On the monotonicity of certain functionals in the theory of analytic functions*, Ann. Univ. Mariae. Curie-Skłodowska **2** (1955), 134–145.