

## SIMPLE PROOFS OF THE CUSA–HUYGENS–TYPE AND BECKER–STARK–TYPE INEQUALITIES

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**Abstract.** In this paper, we respectively give some simple proofs of the Cusa-Huygens- and Becker-Stark-type inequalities presented by Chen and Cheung in [9].

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### REFERENCES

- [1] C. HUYGENS, *Oeuvres Complètes*, 1888–1940, Societe Hollondaise des Science, Haga.
- [2] J. SÁNDOR AND M. BENCZE, *On Huygens' trigonometric inequality*, RGMIA Res. Rep. Collect., **8** (3) (2005), Article 14.
- [3] L. ZHU, *A source of inequalities for circular functions*, Comput. Math. Appl., **58** (2009), p. 1998–2004.
- [4] 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), p. 715–723.
- [5] C. MORTICI, *The natural approach of Wilker-Cusa-Huygens inequalities*, Math. Inequal. Appl., **14** (2011), p. 535–541.
- [6] M. BECKER AND E. L. STARK, *On hierarchy of polynomial inequalities for  $\tan(x)$* , Univ. Beograd. Publ. Elektrotehn. Fak. Ser. Mat. Fiz. No. 602–633 (1978), p. 133–138.
- [7] L. ZHU AND J.-K. HUA, *Sharpening the Becker-Stark inequalities*, J. Inequal. Appl., Article ID 931275 (2010).
- [8] L. ZHU, *Sharp Becker-Stark-type inequalities for Bessel functions*, J. Inequal. Appl., Article ID 838740 (2010).
- [9] C.-P. CHEN AND W.-S. CHEUNG, *Sharp Cusa and Becker-Stark Inequalities*, J. Inequal. Appl., doi:10.1186/1029-242X-2011-136.
- [10] G. D. ANDERSON, M. K. VAMANAMURTHY, AND M. VUORINEN, *Inequalities for quasiconformal mappings in space*, Pac. J. Math., **160** (1) (1993), p. 1–18.
- [11] G. D. ANDERSON, S.-L. QIU, M. K. VAMANAMURTHY, AND M. VUORINEN, *Generalized elliptic integrals and modular equations*, Pac. J. Math., **192** (1) (2000), p. 1–18.
- [12] I. PINELIS, *L'Hospital type results for monotonicity, with applications*, Journal of Inequalities in Pure and Applied Mathematics, **3** (1) (2002), article 5, pp. 1–5.
- [13] I. PINELIS, *“Non-strict” l'Hospital-type rules for monotonicity: intervals of constancy*, Journal of Inequalities in Pure and Applied Mathematics, **8** (1) (2007), article 14, pp. 1–8.
- [14] L. ZHU, *Sharpening Jordan's inequality and the Yang Le inequality*, Applied Mathematics Letters, **19** (3) (2006), p. 240–243.
- [15] H. ALZER AND S.-L. QIU, *Monotonicity theorems and inequalities for the complete elliptic integrals*, Journal of Computational and Applied Mathematics, **172** (2) (2004), p. 289–312.
- [16] J.-L. LI, *An identity related to Jordan's inequality*, International Journal of Mathematics and Mathematical Sciences, Article ID 76782, 2006.
- [17] M. ABRAMOWITZ AND I. A. STEGUN, *Handbook of Mathematical Functions with Formulas, Graphs, and Mathematical Tables*, U. S. National Bureau of Standards, Washington, DC, USA, (1964).

- [18] H. ALZER, *Sharp bounds for the Bernoulli numbers*, Archiv der Mathematik, **74** (3) (2000), p. 207–211.
- [19] B. J. MALEŠEVIĆ, *One method for proving inequalities by computer*, J. Inequal. Appl., Article ID 78691, 2007.