

2012

## The Possible Shapes of Numerical Ranges

J. William Helton

I. M. Spitkovsky

*William & Mary*, [imspitkovsky@gmail.com](mailto:imspitkovsky@gmail.com)

Follow this and additional works at: <https://scholarworks.wm.edu/aspubs>

---

### Recommended Citation

Helton, J. W., & Spitkovsky, I. M. (2011). The possible shapes of numerical ranges. arXiv preprint arXiv:1104.4587.

This Article is brought to you for free and open access by the Arts and Sciences at W&M ScholarWorks. It has been accepted for inclusion in Arts & Sciences Articles by an authorized administrator of W&M ScholarWorks. For more information, please contact [scholarworks@wm.edu](mailto:scholarworks@wm.edu).

## THE POSSIBLE SHAPES OF NUMERICAL RANGES

J. WILLIAM HELTON AND I. M. SPITKOVSKY

*Abstract.* Which convex subsets of  $\mathbb{C}$  are the numerical range  $W(A)$  of some matrix  $A$ ? This paper gives a precise characterization of these sets. In addition to this we show that for any  $A$  there exists a symmetric  $B$  of the same size such that  $W(A) = W(B)$  thereby settling an open question from [2].

*Mathematics subject classification (2010):* Primary 47A12.

*Keywords and phrases:* Numerical range, linear matrix inequalities.

### REFERENCES

- [1] A. BEN-TAL AND A. NEMIROVSKI, *Lectures on modern convex optimization*, MPS/SIAM Series on Optimization, Society for Industrial and Applied Mathematics (SIAM), Philadelphia, PA, 2001, Analysis, algorithms, and engineering applications.
- [2] W.-S. CHEUNG, X. LIU, AND T.-Y. TAM, *Multiplicities, boundary points, and joint numerical ranges*, *Operators and Matrices* **5**, 1 (2011), 41–52.
- [3] K. E. GUSTAFSON AND D. K. M. RAO, *Numerical range. The field of values of linear operators and matrices*, Springer, New York, 1997.
- [4] J. W. HELTON AND V. VINNIKOV, *Linear matrix inequality representation of sets*, *Comm. Pure Appl. Math.* **60**, 5 (2007), 654–674.
- [5] D. HENRION, *Semidefinite geometry of the numerical range*, *Electron. J. Linear Algebra* **20** (2010), 322–332.
- [6] R. A. HORN AND C. R. JOHNSON, *Topics in matrix analysis*, Cambridge University Press, Cambridge, 1991.
- [7] R. KIPPENHAHN, *Über den Wertevorrat einer Matrix*, *Math. Nachr.* **6** (1951), 193–228.
- [8] R. KIPPENHAHN, *On the numerical range of a matrix*, *Linear Multilinear Algebra* **56**, 1–2 (2008), 185–225; Translated from the German by Paul F. Zachlin and Michiel E. Hochstenbach [MR0059242].
- [9] R. T. ROCKAFELLAR, *Convex analysis*, Princeton Landmarks in Mathematics, Princeton University Press, Princeton, NJ, 1997, Reprint of the 1970 original, Princeton Paperbacks.
- [10] P. ROSTLASKI AND B. STURMFELS, *Dualities in convex algebraic geometry*, *Rendiconti di Matematica, Serie VII* **30** (2010), 285–327.