

ON THE ZEROS OF QUATERNIONIC POLYNOMIAL WITH RESTRICTED COEFFICIENTS

BILAL DAR* AND ABDUL LIMAN

Abstract. Location of the zeros of regular polynomial of a quaternionic variable with quaternionic coefficients is addressed in this study. We derive new bounds for the zeros of such polynomials by virtue of the structure of the zero sets in the newly developed theory of polynomials of a quaternionic variable. We will generalize some recently proven results concerning the distribution of zeros of a quaternionic polynomial with restricted coefficients.

Mathematics subject classification (2020): 30E10, 30G35, 16K20.

Keywords and phrases: Quaternionic polynomial, zeros, Eneström-Kakeya theorem.

REFERENCES

- [1] A. AZIZ, B. A. ZARGAR, *Some extension of Eneström-Kakeya theorem*, Glasnik Matematički, **31** (1996), 239–244.
- [2] N. CARNEY, R. GARDNER, R. KEATON AND A. POWERS, *The Eneström-Kakeya theorem of a quaternionic variable*, J. Approx. Theory, **250** (2020), 105–325.
- [3] A. CAUCHY, *Exercices de mathématique*, Oeuvres, **9** (1829), 122.
- [4] G. ENESTRÖM, *Härledning af en allmän formel för antalet pensionärer, som vid en godtycklig tidpunkt förefinnas inom en sluten pensionskassa*, Öfversigt af Vetenskaps-Akademiens Förhandlingar, **50** (1893), 405–415.
- [5] G. ENESTRÖM, *Remarque sur un théorème relatif aux racines de l'équation $a_n x^n + \dots + a_0 = 0$ où tous les coefficients sont réels et positifs*, Tôhoku Math. J., **18** (1920), 34–36.
- [6] G. GENTILI, C. STOPPATO, *Zeros of regular functions and polynomials of a quaternionic variable*, Michigan Math. J., **56** (2008), 655–667.
- [7] G. GENTILI, D. STRUPPA, *A new theory of regular functions of a quaternionic variable*, Adv. Math., **216** (2007), 279–301.
- [8] G. GENTILI, D. STRUPPA, *On the multiplicity of zeros of polynomials with quaternionic coefficients*, Milan J. Math., **76** (2008), 15–25.
- [9] P. R. GIRARD, *The Quaternion Group and Modern Physics*, Eur. J. Phys. **5** (25), 1984.
- [10] N. K. GOVIL, Q. I. RAHMAN, *On the Eneström-Kakeya theorem*, Tôhoku Math. J., **20** (1968), 126–136.
- [11] A. JOYAL, G. LABELLE, Q. I. RAHMAN, *On the location of zeros of polynomials*, Can. Math. Bull., **10** (1967), 53–63.
- [12] S. KAKEYA, *On the limits of the roots of an algebraic equation with positive coefficients*, Tôhoku Math. J., **2** (1912–13), 140–142.
- [13] M. MARDEN, *Geometry of polynomials*, Math. Surveys, **3** (1966).
- [14] G. V. MILOVANOVIĆ, A. MIR, A. AHMAD, *On the zeros of a quaternionic polynomial with restricted coefficients*, Linear Algebra Appl. **653** (2022), 231–245.
- [15] G. V. MILOVANOVIĆ, A. MIR, *On zeros of the regular power series of a quaternionic variable*, Rev. R. Acad. Cienc. Exactas Fís. Nat. Ser. A Math. RACSAM **118**: 47 (2024), 16 pp., <https://doi.org/10.1007/s13398-023-01546-z>.
- [16] G. V. MILOVANOVIĆ, A. MIR, I. HUSSAIN, *On the zeros of polynomials and related regular functions of a quaternionic variable*, Math. Inequal. Appl. **27** (1) (2024), 219–230.

- [17] G. V. MILOVANOVIĆ, A. MIR, *On the zero bounds of polynomials and regular functions of a quaternionic variable*, Appl. Anal. Discrete Math. **17** (2023), 216–231, <https://doi.org/10.2298/AADM220905033M>.
- [18] G. V. MILOVANOVIĆ, A. MIR, *Zeros of one class of quaternionic polynomials*, Filomat **36**: 19 (2022), 6655–6667.
- [19] G. V. MILOVANOVIĆ, D. S. MITRINOVIĆ AND TH. M. RASSIAS, *Topics in polynomials: Extremal problems, Inequalities, Zeros*, World Scientific publishing Co., Singapore, (1994).
- [20] S. MIR, A. LIMAN, *On the Eneström-Kakeya theorem for quaternionic polynomials*, Mediterranean Journal of Mathematics **19** (6) (2022): 264.
- [21] S. MIR, A. LIMAN, *Some extensions of Eneström-Kakeya theorem for quaternionic polynomials*, Korean Journal of Mathematics **30** (4) (2022): 615–628.
- [22] R. MUKUNDAN, *Quaternions: From Classical Mechanics to Computer Graphics and Beyond*, Department of Computer Science, University of Canterbury, Christchurch, New Zealand.
- [23] D. TRIPATHI, *A note on Eneström-Kakeya theorem for a polynomial with quaternionic variable*, Arab. J. Math., **9** (2020), 707–714.