

INDECOMPOSABLE MATRICES DEFINING PLANE CUBICS

ANITA BUCKLEY

Abstract. In this article we find all (decomposable and indecomposable) 6×6 linear determinantal representations of Weierstrass cubics. As a corollary we verify the Kippenhahn conjecture for M_6 .

Mathematics subject classification (2010): 14M12, 14H52, 14H60.

Keywords and phrases: determinantal representations, plane cubics, vector bundles, Kippenhahn conjecture.

REFERENCES

- [1] M. ATIYAH, *Vector bundles over an elliptic curve*, Proc. London Math. Soc. (3), **7** (1957), 414–452.
- [2] J. BACKELIN, J. HERZOG, AND H. SANDERS, *Matrix factorizations of homogeneous polynomials*, Algebra Some Current Trends **1352**, Lecture Notes in Mathematics, Springer (2006), 1–33.
- [3] A. BEAUVILLE, *Determinantal Hypersurfaces*, Michigan Math. J. **48** (2000), 39–63.
- [4] A. BEAUVILLE, *Vector bundles on curves and generalized theta functions: recent results and open problems*, Complex Algebraic Geometry, MSRI Publications **28** (1995), 17–33.
- [5] A. BUCKLEY AND T. KOŠIR, *Plane Curves as Pfaffians*, Annali Della Scuola Normale Superiore di Pisa-Classe di Scienze (2010).
- [6] R. J. COOK AND A. D. THOMAS, *Line bundles and homogeneous matrices*, Quart. J. Math. Oxford Ser. (2) **30** (1979), 423–429.
- [7] L. E. DICKSON, *Determination of All General Homogeneous Polynomials Expressible as Determinants with Linear Elements*, Trans. Amer. Math. Soc. **22** (1921), 167–179.
- [8] D. EISENBUD, *Homological algebra on a complete intersection, with an application to group representations*, Trans. Amer. Math. Soc. **260** (1980), 35–64.
- [9] D. EISENBUD, *The Geometry of Syzygies: A Second Course in Algebraic Geometry and Commutative Algebra*, Graduate Texts in Mathematics, Springer (2005).
- [10] H. GRASSMAN, *Die stereometrischen Gleichungen zweiten Grades, und die dadurch erzeugten Oberflächen*, J. Reine Angew. Math. **49** (1855), 47–65.
- [11] R. KIPPENHAHN, *Über den Wertevorrat einer Matrix*, Mathematische Nachrichten Volume 6, **3–4** (1951), 193–228.
- [12] T. J. LAFFEY, *A counterexample to kippenhahn’s conjecture on hermitian pencils*, Lin. Alg. Appl. **51** (1983), 179–182.
- [13] P. LANCASTER AND L. RÖDMAN, *Canonical forms for symmetric / skew-symmetric real matrix pairs under strict equivalence and congruence*, Linear Algebra Appl. **406**, (2005), 1–76.
- [14] CHI-KWONG LI AND ILYA SPITKOVSKY, *Equality of Higher Numerical Ranges of Matrices and a Conjecture of Kippenhahn on Hermitian Pencils*, Lin. Alg. Appl. **58** (1998), 323–349.
- [15] D. MUMFORD, *Abelian varieties*, Tata institute of fundamental research, Bombay, 1970.
- [16] T. NETZER AND A. THOM, *Polynomials with and without determinantal representations*, Linear Algebra Appl. **437** (2012), 1579–1595.
- [17] G. V. RAVINDRA AND AMIT TRIPATHI, *Torsion points and matrices defining elliptic curves*, International Journal of Algebra and Computation Vol. 24, **6**, 2014.
- [18] R. QUAREZ, *Symmetric determinantal representation of polynomials*, Linear Algebra Appl. **436** (2012), 3642–3660.
- [19] H. SHAPIRO, *A conjecture of Kippenhahn about the characteristic polynomial of a pencil generated by two Hermitian matrices, I and II*, Lin. Alg. Appl. **43** (1982), 201–221 and **45** (1982), 97–108.

- [20] H. SHAPIRO, *Hermitian pencils with a cubic minimal polynomial*, *Lin. Alg. Appl.* **48** (1982), 81–103.
- [21] F. SCHUR, *Ueber die durch collineare Grundgebilde erzeugten Curven und Flächen*, *Mathematische Annalen*, Vol. 18 **1** (1881), 1–32.
- [22] V. VINNIKOV, *Complete description of determinantal representations of smooth irreducible curves*, *Lin. Alg. Appl.*, **125** (1989), 103–140.
- [23] V. VINNIKOV, *Self-adjoint determinantal representations of real irreducible cubics*, *Operator Theory: Advances and Applications*, **19** (1986), 415–442.
- [24] V. VINNIKOV, *LMI representations of convex semialgebraic sets and determinantal representations of algebraic hypersurfaces: Past, present, and future*, *Operator Theory: Advances and Applications*, **222** (2012), 325–349.
- [25] W. C. WATERHOUSE, *The codimension of singular matrix pairs*, *Lin. Alg. Appl.* **47** (1984), 227–245.