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## Aradhita Chattopadhyaya - Instanton partition functions in Vafa Witten theory

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We analyze the coefficients of partition functions of Vafa-Witten theory for the complex projective plane  $\mathbb{CP}^2$ . We first introduce the topologically twisted super Yang Mills theory also called Vafa Witten theory on  $\mathbb{CP}^2$  whose instanton partition functions can be obtained using algebraic geometry methods. We experimentally study the growth of the coefficients for gauge group SU(2) and SU(3), which are examples of mock modular forms of depth 1 and 2 respectively. We also introduce the notion of "mock cusp form", and study an example of weight 3 related to the SU(3) partition function. Numerical experiments on the first few coefficients suggest that the coefficients of a mock modular form of weight k grow as the coefficients of a modular form of weight k, that is to say as  $n^{k-1}$ . On the other hand the coefficients of the mock cusp form appear to grow as  $n^{3/2}$ , which exceeds the growth of classical cusp forms of weight 3. We provide bounds using saddle point analysis and estimation of the size of Durfee square which exceed the experimental observation.

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