

Elliptic Functions And Rings Of Integers

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Fast Computation of Complete Elliptic Integrals and Jacobian Elliptic Functions

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Abstract As a preparation step to compute Jacobian elliptic functions efficiently, we created a fast method to calculate the complete elliptic integral of the first and second kinds, $K(m)$ and $E(m)$, for the standard domain of the elliptic parameter, $0 < m < 1$. For the case $0 < m < 0.9$, the method utilizes 10 pairs of approximate polynomials of the order of 9 to 19 obtained by truncating Taylor series expansions of the integrals. Otherwise, the associate integrals, $K(1-m)$ and $E(1-m)$, are first computed by a pair of the approximate polynomials and then transformed to $K(m)$ and $E(m)$ by means of Jacobi's nome, q , and Legendre's identity relation. In average, the new method runs more-than-twice faster than the existing methods including Cody's Chebyshev polynomial approximation of Hastings type and Innes' formulation based on q -series expansions. Next, we invented a fast procedure to compute simultaneously three Jacobian elliptic functions, $\operatorname{sn}(u|m)$, $\operatorname{cn}(u|m)$, and $\operatorname{dn}(u|m)$, by repeated usage of the double argument formulae starting from the Maclaurin series expansions with respect to the elliptic argument, u , after its domain is reduced to the standard range, $0 \leq u < K(m)/4$, with the help of the new method to compute $K(m)$. The new procedure is 25-70 % faster than the methods based on the Gauss transformation such as Balluel's algorithm, `amcdm`, quoted in the Numerical Recipes even if the acceleration of computation of $K(m)$ is not taken into account.

Keywords methods: numerical

1 Introduction

1.1 Jacobian Elliptic Functions

Three Jacobian elliptic functions, $\operatorname{sn}(u|m)$, $\operatorname{cn}(u|m)$, and $\operatorname{dn}(u|m)$, are special functions used in various fields of mathematical physics and engineering [2, 13]. In celestial mechanics, they appear frequently in orbital mechanics (1) to solve a high-order solution

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