POISSON SERIES PROCESSOR AND ITS APPLICATION IN CELESTIAL MECHANICS

T. V. IVANOVA

Institute of Theoretical Astronomy of the Russian Academy of Sciences, St.Petersburg

E-mail 1197@iipah.spb.su

A specialized Poisson Series Processor (PSP) is proposed. It is a typical software for the implementation of analytical algorithms of Celestial Mechanics. The PSP is a new realization and development of well known Universal Poisson Processor (Tarasevich, 1979; Ivanova, 1979; Babaev et al., 1980) which has been existed on the BESM-6 computer. The PSP is designed for manipulating long Poisson (polynomial-trigonometric) series with the rational or floating-point coefficients. The Poisson series are the main mathematical objects of analytical celestial mechanics but the PSP is by no means restricted to this field of application. All the programs of the PSP are general and may be used in theoretical mechanics and physics.

The most important characteristics of the PSP are as following:

1) The PSP is written in standard FORTRAN-77 and practically all the subroutines are machine-independent.

2) The PSP runs under MS-DOS on IBM PC and under UNIX on a Sun workstation.

3) The PSP uses the linked list representation of the series for the dynamical memory allocation.

4) The coefficients of Poisson series are rational or floating-point numbers. In order to increase the range of the representation of the rational coefficients the double precision floating-point numbers for exact operations on these coefficients have been used. At present the computer operations on arbitrary length integer and rational numbers are working out.

5) The PSP has no restriction on the number of polynomial and angular variables and on the ranges of the associated indices which may be prescribed by the user for any specific problem.

6) Each term of the series is characterized by the analytical order of smallness which is defined as the sum of the polynomial indices multiplied by the weight functions of the corresponding variables.

7) All the computer operations on the series are formal. The smallness of a term is determined by its analytical order of smallness and the numerical estimation of its coefficient.

8) The list of basic operations of the PSP includes the standard arithmetic operations on series, the partial differentiation and integration with respect to polynomial and trigonometric variables, the total differentiation and integration with respect to time under the assumption that all the trigonometric variables are linear functions of the time with numerical values for the frequencies, raising to any integer, rational and real powers, binomial and Taylor expanding up to prescribed order, substituting other series in place of power and trigonometric variables, fast evaluating of the series in fixing values of some variables, converting of the series, different sortings and selectings, etc. The PSP allows to realize input and output of series in any format or unformatted mode and to type them in the natural mathematical form.

9) The PSP allows to user to write own procedures without any difficulty.

10) Due to the hierarchical architecture of the PSP it is possible easily to modify the

system for the objects slightly different from standard Poisson series (for instance, for manipulating the exponents instead of the trigonometric functions or for changing the type of coefficients, etc.) or for other representation of Poisson series in the computer's memory. Also it is easily to adapt the PSP for other computers. 11) A special input language is working out by E. Yu. Pariiskaya. It will allow to user to write his task in the form similar to the mathematical one by introducing new data types such as power and trigonometric variables, series and rational numbers and by creating algebraic library functions.

The Keplerian Processor and analytical generator of special celestial mechanics functions based on the PSP are proposed too. They may be regarded as an illustration of practical application of the PSP. These systems are designed for implementing the expansions of the most important mathematical functions for celestial mechanics such as Legendre and Gegenbauer polynomials, Bessel and spherical functions, etc., for constructing the expansions of the elliptic motion functions of the unperturbed two-body problem and the expansions of the typical celestial mechanics functions such as Hansen coefficients, Newcomb operators, Kaula inclination functions and their generalizations, etc. The software of this sort is the necessary tool for the construction of general perturbation solutions in all analytical celestial mechanics problems.

The most powerful test of the PSP was to solve the problem on the transformation of terrestrial dynamical time to barycentric dynamical time. The analytical complete planetary theory VSOP 87 (Bretagnon, 1987) and Lunar theory ELP 2000 (Chapront-Touse and Chapront, 1983) were used to realize this analytical transformation.

References

Babaev I. O., Brumberg V. A., Ivanova T. V., Skripnichenko V. I., Tarasevich S. V. and Vasiliev N. N. : 1980, "Universal Poissonian Processor (UPP)", *Internat. Conf. on Systems and Techniques of Analytical Computing and their Applications in Theoretical Physics*, 80, Dubna

Bretagnon P., Francou G. : 1988, "Planetary theories in rectangular and spherical variables. VSOP 87 solutions" *Astron. Astrophys.*, **202**, 309

Chapront-Touze M., Chapront J. : 1983, "The Lunar ephemeris ELP 2000" *Astron. Astrophys.*, **124**, 50

Ivanova T. V. : 1979, "Keplerian processor and analytical generator of celestial mechanics functions" *Algorithms of Celestial Mechanics*, **28**, ITA, Leningrad

Tarasevich S. V. : 1979,"UPP – Universal Poissonian Processor", *Algorithms of Celestial Mechanics*, **27**, ITA, Leningrad