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Editors

Vahe G. Gurzadyan
Yerevan Physics Institute
Yerevan, Armenia

Robert T. Jantzen
Department of Mathematical Sciences
Villanova University
Villanova, PA 19085 USA

Editor & Series Editor

Remo Ruffini
Center for Relativistic Astrophysics
University of Rome "La Sapienza"
Rome 00185 Italy

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RECENT DEVELOPMENTS IN THE SYSTEM ORTOCARTAN

ANDRZEJ KRASIŃSKI
N. Copernicus Astronomical Center, Polish Academy of Sciences, Bartycka 18, 00 716 Warszawa, Poland
E-mail: akr@camk.edu.pl

This communication presents developments done after the previous published description [1]. More details can be found in Ref. 2. The following new programs exist now:

1. Calculating the kinematic tensors of the flow and their evolution equations.

The input data for the program are the orthonormal tetrad components of the metric and of the velocity field (plus any kind of substitutions, as described in Ref. 1). The quantities calculated are: the expansion scalar, the acceleration vector, the rotation tensor and scalar, the shear tensor and scalar, the electric and magnetic components of the Weyl tensor, the Raychaudhuri equation, the other evolution equations, and the contraint equations, all as in Ref. 3.

2. Calculating the curvature tensor corresponding to given connection coefficients in any number of dimensions.

The connection coefficients are assumed torsion-free, but need not be metrical. This was written as an auxiliary program for another research, and hence the limitation to zero torsion. It may be removed quite easily.

3. Calculating the Lagrangian for a given metric by the Landau-Lifshitz prescription.

This Lagrangian is not covariant, but contains no second derivatives of the metric, and so it can be directly inserted in the Euler-Lagrange equations (only in those situations, of course, where lagrangian methods do work).

4. Calculating the Euler-Lagrange equations from a given Lagrangian.

This calculation is done only for ordinary differential equations, i.e. the Lagrangian variables must be functions of only one independent variable. This is a limitation resulting from the application for which this program was written, and there are no basic obstacles to extend the algorithm to a larger number of independent variables. The number of the Lagrangian functions is arbitrary.

5. Verifying first integrals for sets of ordinary differential equations of second order.

The user defines the names of the functions $f^i(t)$ and the hypothetical first integral $Q = Q_{ij} f^i{}_{,t} f^j{}_{,t} + L_i f^i{}_{,t} + E$ (it must be a polynomial of second or first degree in the $f^i{}_{,t}$ with coefficients depending on t and f^i only). The program calculates the total derivative dQ/dt and then the user specifies the second derivatives $f^i{}_{,tt}$, thus making use of the set of equations. Any other substitutions can be inserted in the same way as described in Ref. 1. The number of functions in the set is arbitrary, but the highest order of an equation in the set must be 2. The program may be used either for verifying given first integrals or for finding new integrals of this form. In the latter application, the program prints the partial differential equations to be obeyed by the functions Q_{ij}, L_i and E.

6. Factoring out a given factor F in intermediate expressions.

The program automatically factors out the highest power of F that is a common factor in any given sum. This convenience was created for one specific application, but it is not included in the other programs described here because it tends to slow down the calculation. Dividing by a given factor (without automatic detection of higher powers of it) can be easily done using the substitutions by pattern-matching (see Ref. 1).

7. Conveniences.

For all the programs described above, the results of the calculation may be printed or stored on a disk in one of the 3 formats: 1. The ordinary mathematical format, readable for humans; 2. The input format to be directly used as data for any Ortocartan program; 3. The Latex format that may be inserted in any Latex file as part of a text for publication.

8. Availability.

The programs are implemented in Codemist Standard Lisp that can be installed on any computer that uses either Linux or Windows 98 as the operating system. See Ref. 2 for more details.

References

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2. A. Krasiński, *Gen. Rel. Grav.* **33**, no1 (2001, in press).
3. G. F. R. Ellis, in *General relativity and cosmologgy. Proc. Course 47 of the Fermi School.* Academic Press 1971, p. 104.