the handling of special functions. The capabilities available in present systems do not always reflect the state of knowledge in algebraic algorithm design. For instance new powerful methods to solve differential equations in closed forms have been found but are not yet fully implemented.

### Prototypical Applications

CAS have been applied to many different fields of physics [1]. In high energy physics, a breakthrough application has been to perform the tedious algebra arising from the calculation of Feynman diagrams in quantum electrodynamics and to determine the theoretical values of the anomalous magnetic moments of the electron and muon and of the Lamb-shift effect at high orders of the perturbative expansion. Also noticeable are several diagram calculations in quantum chromodynamics and the two loops computation in the standard SU(2) × U(1) model.

In celestial mechanics an outstanding result is the duplication in 1970 by Deprit and co-workers, of the 1867 work of Delaunay on the calculation of the orbit of the moon with corrections up to order 9. To get an error free result took them only 20 hours on a mini-computer instead of 20 years of Delaunay's life. In this example, the capability to implement a Poisson series representation in a CAS was the key to their success. The same type of computation is applicable to the orbit of satellites for instance.

In general relativity specialized (CLAM, SHEEP,...) as well as general purpose systems such as MACSYMA are used to solve the basic equations starting with the definition of the covariant metric tensor which determines the length of a line element in space. Then, the Christoffel's symbol and Rieman's, Ricci's and Einstein's tensors are obtained and the 10 Einstein's field equations solved. CAS are useful to point out the possible equivalence of some metrics. Many other applications have been reported on.

Since CAS are devoted to symbolic mathematics, they are obviously used by mathematicians as well. It is worthwhile to notice that although they encompass only a little part of the whole knowledge of mathematicians, they can be used to solve, from scratch, some of the "open problems" in the relevant section of the *American Mathematical Monthly*.

A general feature of applications is that most of them involve simple and straightforward but long and tedious algebra. While many years ago the use of a CAS was always acknowledged in published papers (several hundreds of them) nowadays, they are often regarded as casual tools and no longer referenced.

### New Frontiers

Despite the many successful applications of CAS in many fields of science, they have obviously some drawbacks. Apart from technical ones which are irrelevant for this brief survey, the major weakness is probably that, surprisingly enough, they know very little mathematics. To bypass this limitation, two different research directions are possible and investigated. The first is to concentrate on enlarging the library of available algebraic algorithms and procedures. As outlined previously, several breakthroughs have been achieved in the design of algebraic algorithms and there is no reason to believe that this trend will stop. This ensures that existing CAS will remain alive and expand in the foreseeable future. An alternative approach is to consider that CAS are not only suitable to manipulate formulae as they exclusively do today, but that they must also accommodate the concept of mathematical objects and their associated properties. The IBM project SCRATCHPAD, which is well under way, is the first CAS of this generation. But, it is possible further to enlarge the concepts upon which computer algebra is based by stating that its ultimate goal is to represent and manipulate mathematical knowledge. Then, artificial intelligence techniques become compulsory. Unfortunately, mathematics is a very complex domain and the techniques developed for the usual domains of artificial intelligence such as expert systems or robotics are not elaborated enough for its needs. This latter trend [3] is thus a longer term research track which aims to design completely new types of mathematical systems but not to replace present CAS.

Further information and references are available from the author.


#### REFERENCES

[1] *Computer Algebra: Symbolic and Algebraic Computation* 2nd ed., Eds. B. Buchberger *et al.* (Springer-Verlag) 1983.

[2] Yun D.Y.Y. and Stoutmyer D.R., 'Symbolic Mathematical Computation', *Encyclopedia of Computer Science and Technology*, Eds. Belzer, Holzman & Kent, **15** (1980) 235-310.

[3] Calmet J., "Intelligent Computer Algebra Systems: Myth, Fancy or Reality?' To appear in *Proc. of the Trends in Computer Algebra,* Conference. Bad Neuenahr, FRG. May 1987, LNCS (Springer-Verlag) 1988.


## A Delegate Enquires

**Dear Sir**

*May I use your columns to write to the Individual Ordinary Members of the EPS? I am a recently-elected delegate of the IOM's to the Council of the EPS. I believe I could do this job more effectively (and this goes for other Council members too) if any IOM with strong views about any aspect of how the EPS runs its affairs — conferences, journals, general structure (including financial matters), or indeed anything else — would write to me about it. I can then form a better idea of what EPS members' attitudes are on the issues they find important. The next Council meeting is on 24-25 March 1988, so it would be especially helpful to have any comments before then.*

*Such comments need not, of course, be restricted to remarks (favourable or unfavourable) about current practices; ideas for the future development of the EPS and views on broader issues would also be valuable. I should mention further that I am not intending in the least to suggest that adequate channels of communication do not exist already in the EPS; it is simply that I personally feel I could play a more useful role as a delegate if I were better informed.*

*Yours sincerely,*


**Derek N. Stacey**
**Clarendon Laboratory,**
**Oxford OX1 3PU, England**


## Optics Elections

Elections will be held shortly of the 12 members of the Board of the **Optics Division**. Candidates proposed by the Provisional Board are listed below, but additional nominations are invited.

These should be supported by three members of the Division coming from at least two countries and the candidates agreement to stand should be appended.

J. Bescos, Optics Institute, Madrid
K. Biedermann, Royal Inst. of Technology, Stockholm
J.J.M. Braat, Philips Research Lab., Eindhoven
J. Bulabois, Franche-Comté Univ., Besançon
R. Dändliker, Inst. of Microtechniques, Neuchâtel
J.C. Dainty, Imperial College, London
H.A. Ferwerda, University, Groningen
J.-P. Huignard, Thomson-CSF, Orsay
O.J. Løkberg, Norway
E.R. Pike, Kings College, London
A. Podmaniczky, Technical University, Budapest
V. Russo, IROE, Florence
O.D.D. Soares, University, Porto

Nominations should be sent to the EPS Secretariat by the end of March, 1988.