Binary Star Orbits for Amateurs:

By
Frank Smith

Disclaimer

I'm an amateur, so I may (probably) have made errors

Mathematica defaults to four five decimals, but of course, we're not getting that level of precision

About me

- **My one claim to fame is that I was a national finalist for amateur use of the Hubble Space telescope (cycle 0)**
  - **For ten years or so I've been measuring double stars using an Internet telescope service.**
  - **I've had six articles published in JDSO.**

It's all going away!

The iTelescope service caters to "pretty pictures" people. That limits my measures to wide doubles (10 arc-sec or more)

With Gaia becoming operational, there is no point on me paying for measures no one will ever use.

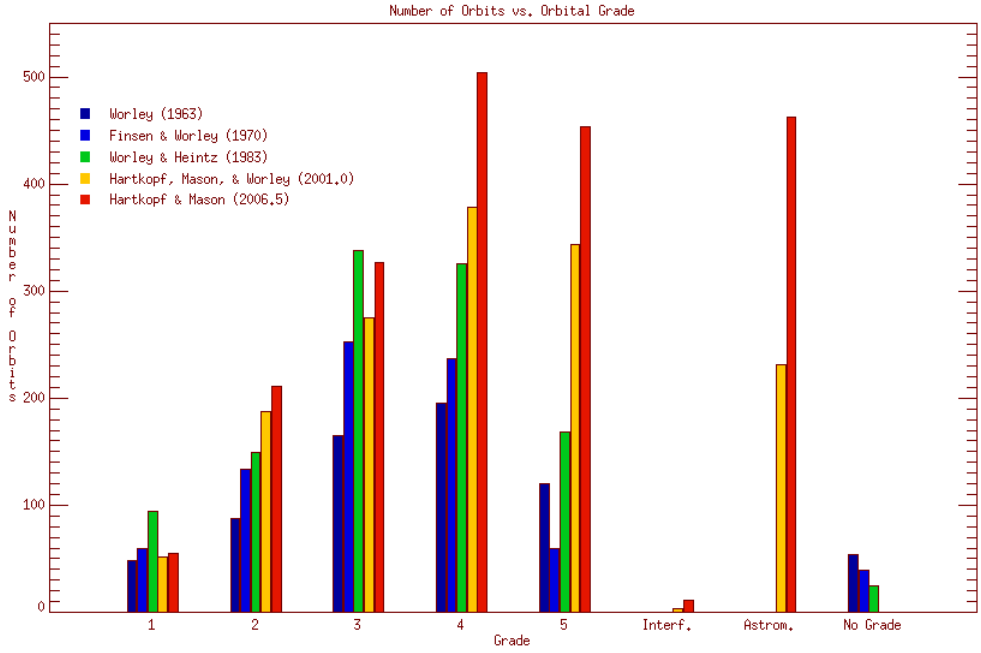
Sooo, I was looking for something I could still do in double star research.

I started using *Mathematica* to compute Rectilinear Elements of wide doubles, using WDS data and some of my own measures.

Also, I started writing *Mathematica* notebooks to compute binary star orbits, with the idea of a deeper understanding of double stars. That turned out to be much more demanding than I orginally thought.

At the Harkness House Binary Star workshop Dr. Mason stated there are only about 30 “definitive” double star orbits.

As of 11 September 2014, the Sixth Catalog included 2,518 orbits of 2,413 systems (from a “master file” database currently containing 7,526 orbits)



I'm using *Mathematica*, but other choices could be:

- **Mathcad**
- **Freeware "R" (note *Mathematica* can now call R routines)**

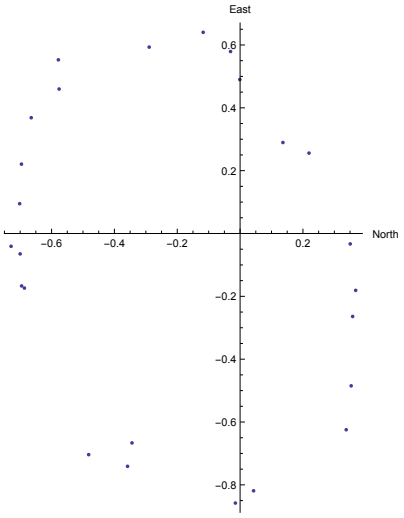
In 1903 mathematician F.N. Cole factored the Mersenne Prime number 2^67-1 by hand in front of a meeting of the American Mathematical Society. He received a standing ovation. It had taken him twenty years of Sunday afternoons to factor the number.

```
ta = SessionTime[];
Mersenne Prime

2^67 - 1

FactorInteger[2^67 - 1]
tb = SessionTime[];
 (tb - ta) / 60
```

The basic problem is finding the true orbit from the observations.

The observations depict the apparent orbit against the background sky.

Polar plot graph of latest observations of BU733 AB



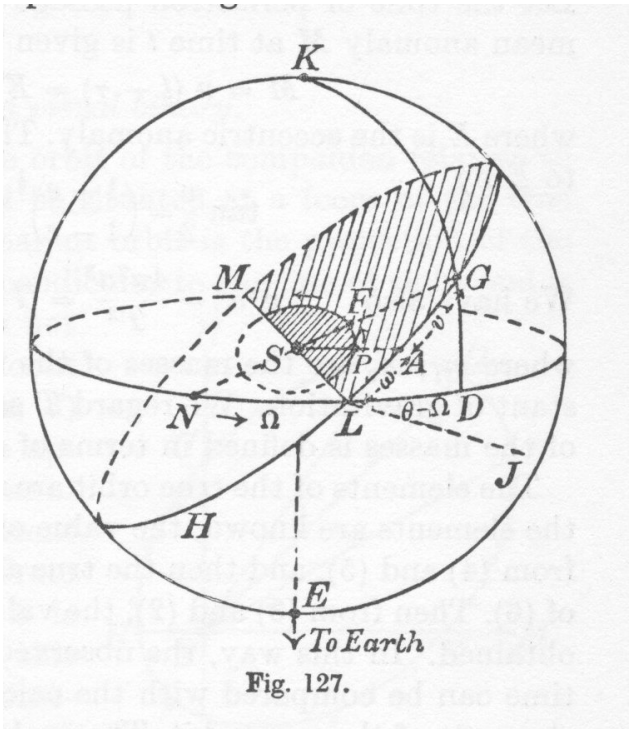
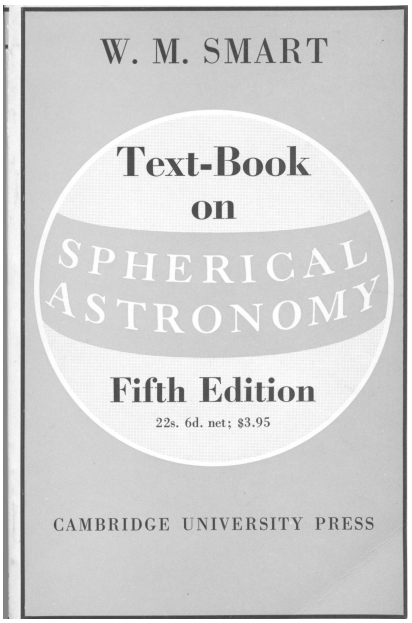


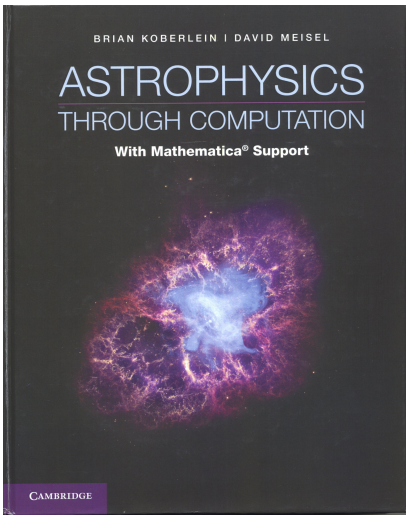
Fig. 127.

Methods of Computing an orbit

1. Zwiers' Method
2. Thiel-Innes Method
3. Kowalasky Method (the one I used)

The programs I'm going to show are modification of a *Mathematica* notebook by Koberlein and Meisel using the classic text by W.M Smart. Text-Book on Spherical Astronomy, Fifth Edition. My program is a modified version of VisBin.nb found in Koberlein & Meisel, Astrophysics through Computation, Cambridge University Press, 2013. I re-wrote Koberlein & Meisel's notebook to be more orbit computation oriented.




BRIAN KOBERLEIN I DAVID MEISEL
ASTROPHYSICS
THROUGH COMPUTATION
With Mathematica© Support
CAMBRIDGE

Computing an orbit is not trivial and decisions by the investigator need to be done at several points. WDS measures are not sufficient to decide ambiguities in:

Nodal angle Ω
Argument of periapsis ω
Orbital eccentricity e

From Koberlein & Meisel:

"As one goes through the various solutions, it must be remembered that in the derivations, Smart had to take squares of quantities in order to combine sines and cosines. This means that there will always be multiple roots and one has to make decisions at every stage about the correct value to use subsequently. Many times those doing orbit solutions will also have spectroscopic or other astrometric information to guide their decisions."

My collision with speckle interferometry.

I started reading papers about orbit contribution. One of the most influential was:

“Binary Star Orbits from Speckle Interferometry. VII. The Multiple System XI Ursae Majoris” Mason, McAlister & Hartkopf, Astronomical Journal, Volume 109, No. 1.

Note that in the article MM&H say “Visual observations covering the time base of the speckle data were given zero weight.

What could possibly go wrong?

Show notebooks on:

STF 1523 AB (XI Ursae Majoris)

BU 733AB

Conclusions

1. The group should be able to publish meaningful orbits.

2. Emphasize quality not quantity.

3. Instead of new orbits work to revise an already published "Grade 3 or below" full orbit that is about 10 years or so old.

4. Use new speckle data and other speckle data developed since the orbit was last published. If the new elements show a better o-c, then the new orbit is probably an improvement and would be publishable.