LIGHT BUCKET ASTRONOMY

Lunar Occultation Theory and Practice

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**2010-2011 Alt-Az Initiative Hawaii Conference on Light Bucket Astronomy**

Agenda

- Occulted Object Science Potential
- IOTA Activities
- Hardware and Software Tools
- Demo (time permitting)

Fresnel Diffraction

- Moon's edge acts as straight edge in vacuum of space

- Roughness of limb not a serious problem

- Diffraction patterns add linearly for multiple components
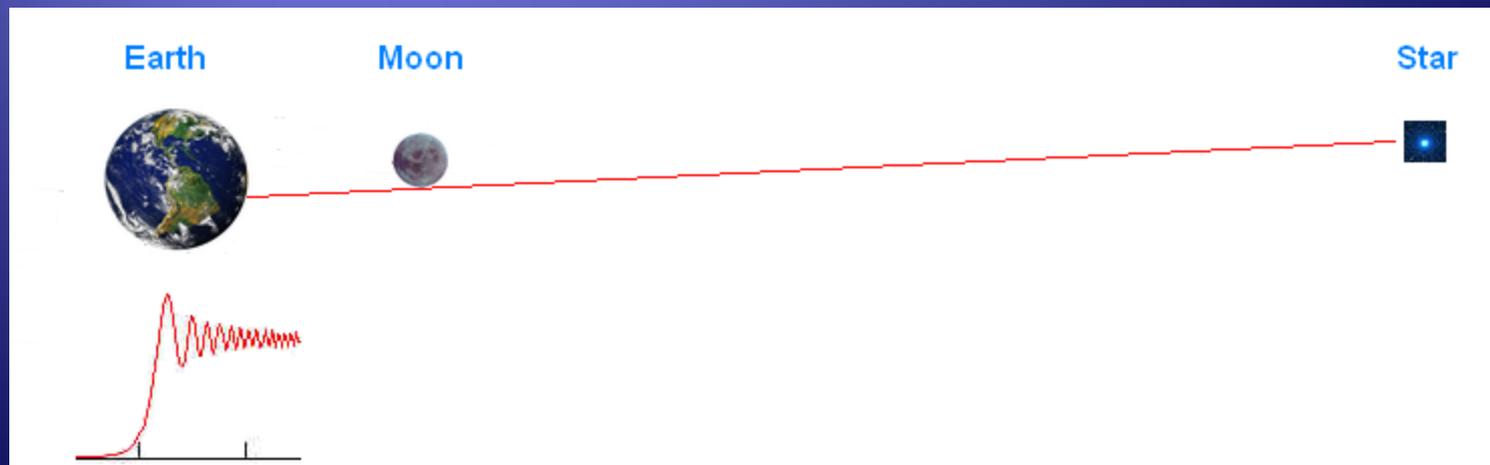
Fresnel Diffraction

Dependencies on bandpass and geometry

The effect of a finite passband

$$I(x) = I_0 \left| \int_{-\infty}^{x} e^{\left(\frac{i\pi u^2}{L\lambda}\right)} du \right|^2$$

Legend: 500 nm, 500-550 nm, 400-600 nm, 400-800 nm

Y-axis: Intensity of light

X-axis: Distance from edge of geometric shadow (meters)

Adapted from: Michael Richmond, 2005, http://spiff.rit.edu/richmond/occult/bessel/bessel.html
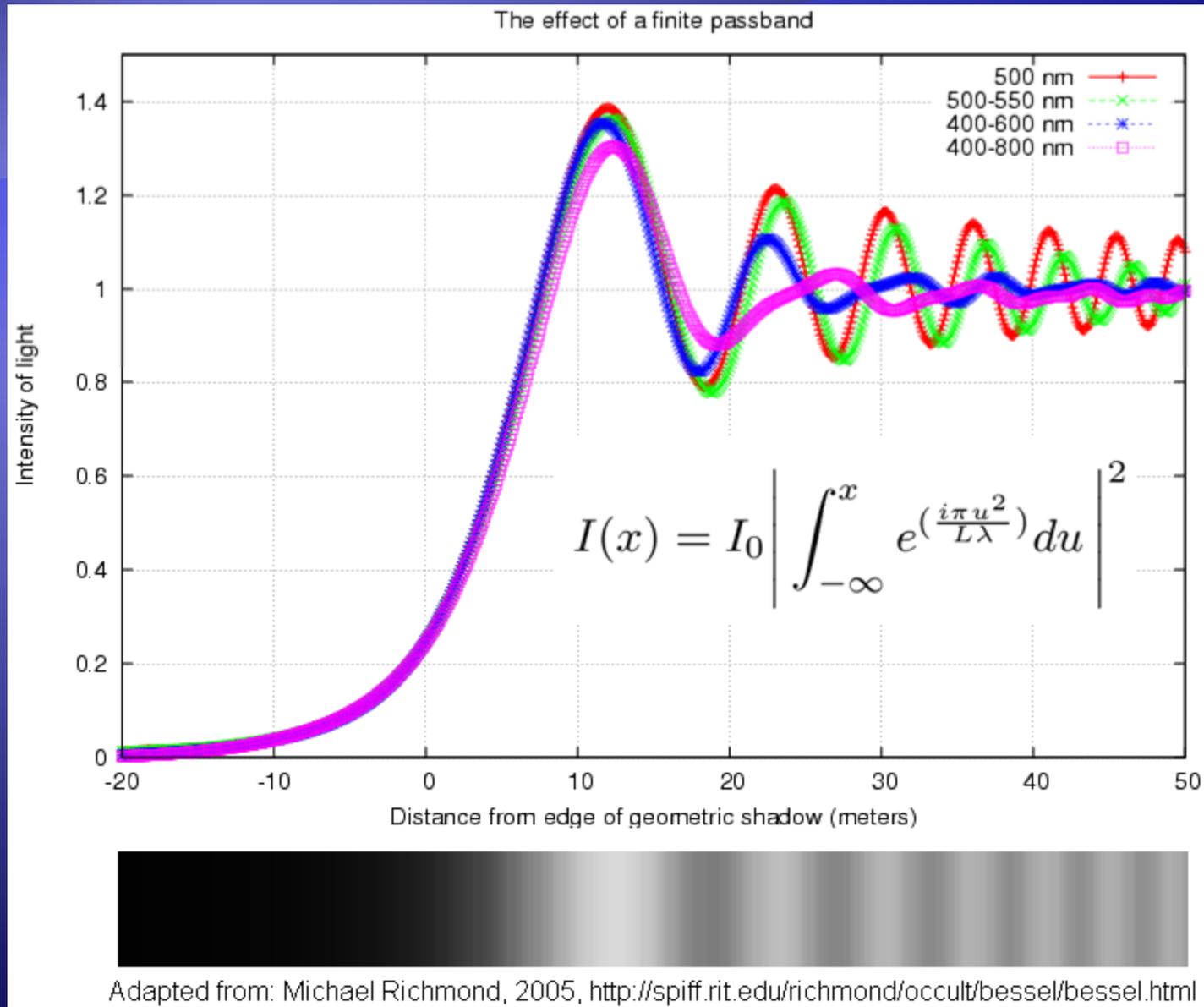
Some Occulted Object Science Potentials with a Sufficient SNR

- Presence/absence of stellar companions
  - Separations, PA, relative luminosity
- Stellar sizes
- Limb darkening laws
- Presence of plages and spots
- Circumstellar disks
- Detection of hot Jupiters

Your local advancing lunar edge

Star

Spot

My local advancing edge
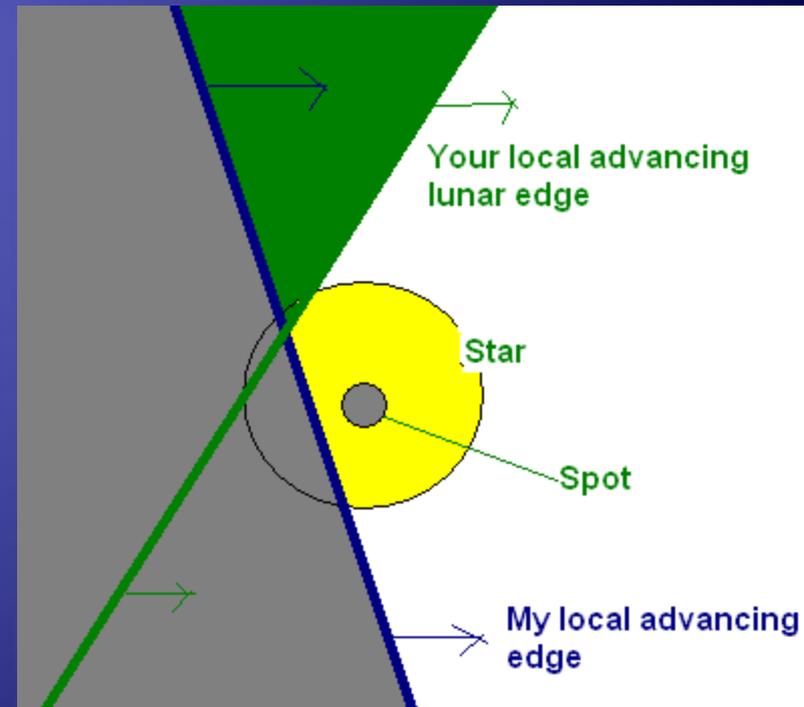
Lunar Occultations Examples

Theoretical diffraction light curves for different sized stars (0.1 to 30-mas)

Star size in ", limb darkening = 0, Bandpass 320-720nm

Legend:
Fl(– xg, 0.0001)
Fl(– xg, 0.002)
Fl(– xg, 0.005)
Fl(– xg, 0.010)
Fl(– xg, 0.030)

xg

Distance on ground (meters)
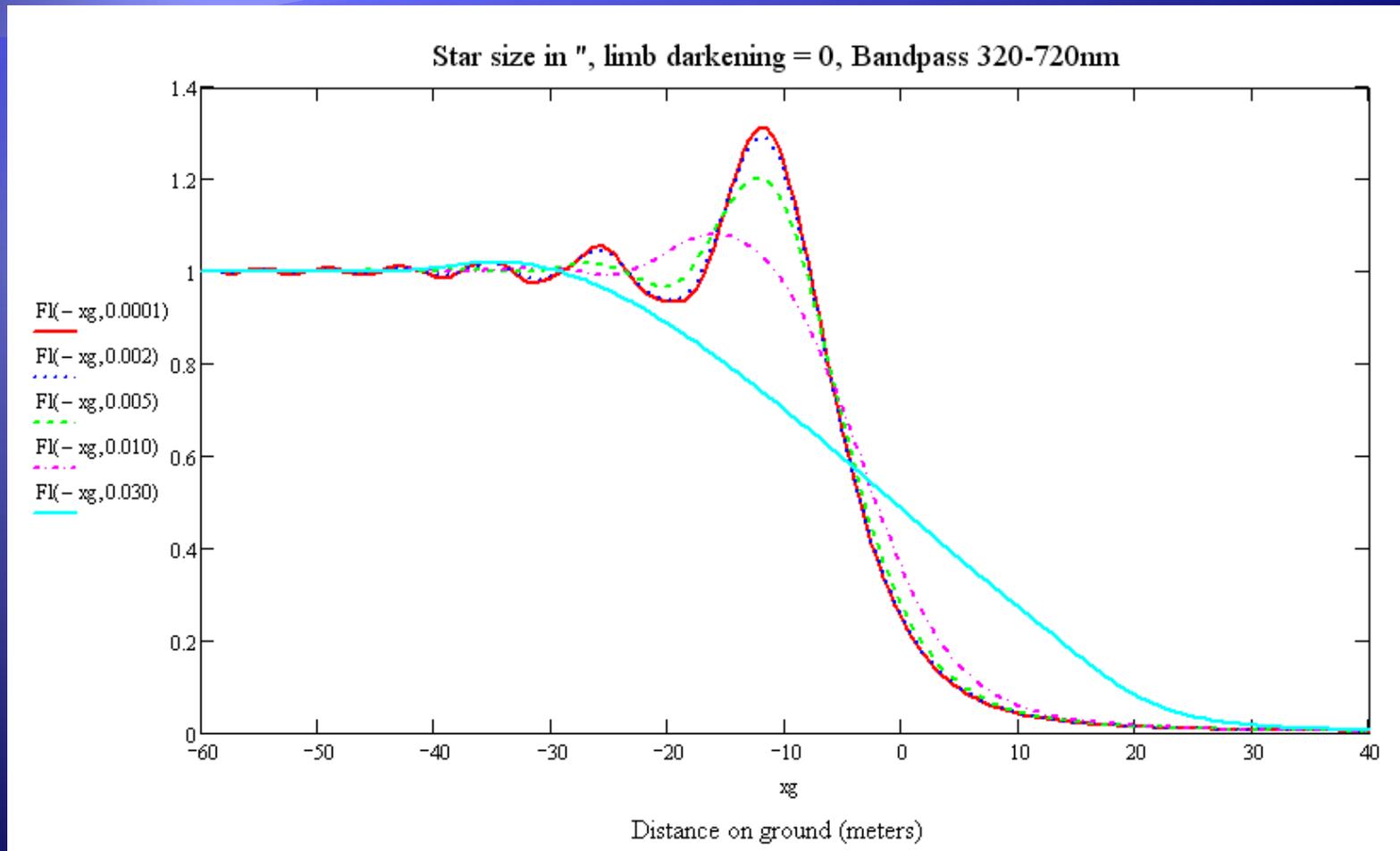
Lunar Occultations - Binaries

Theoretical diffraction light curves for three different binary systems
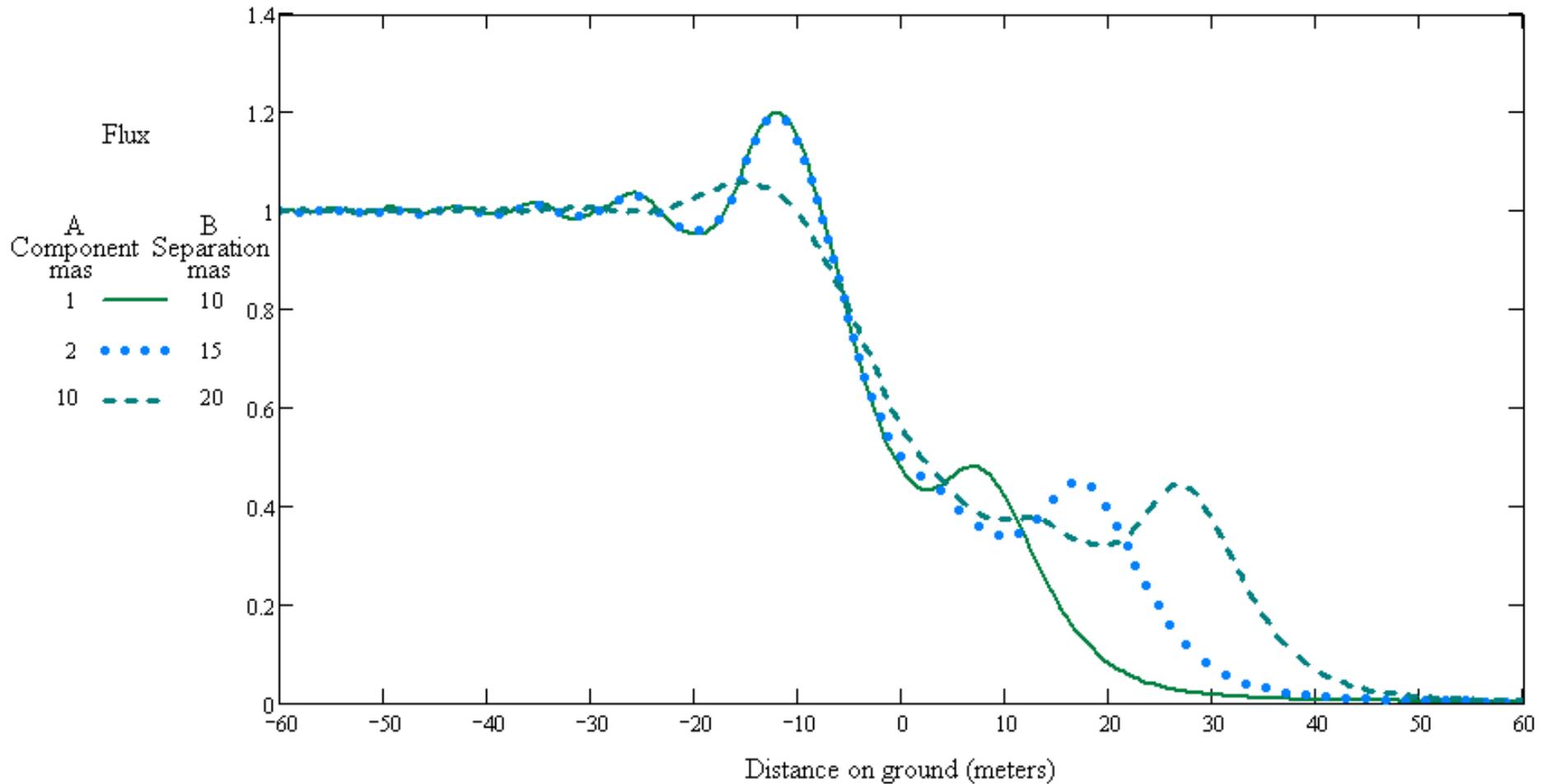
Examples
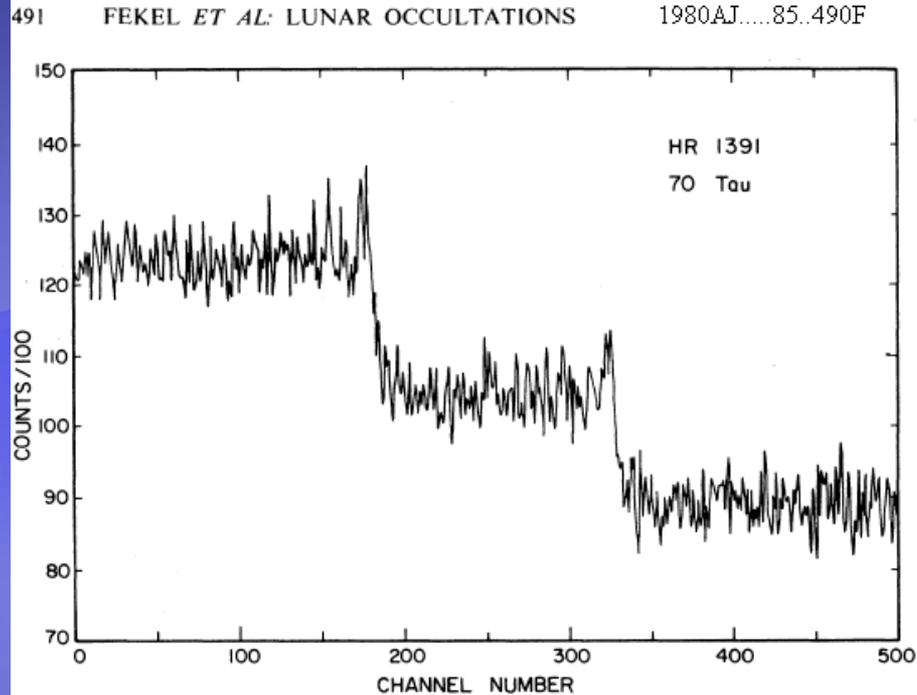
HR 1391
70 Tau

FIG. 1. A plot of the unprocessed data for run 5103 on HR 1391. Each channel number corresponds to a 5-ms integration. The detected photons per integrating unit are shown. The binary nature of HR 1391 is quite obvious.

D. Herald, et. al.

A New Double Star from Lunar Occultations: HIP 87306
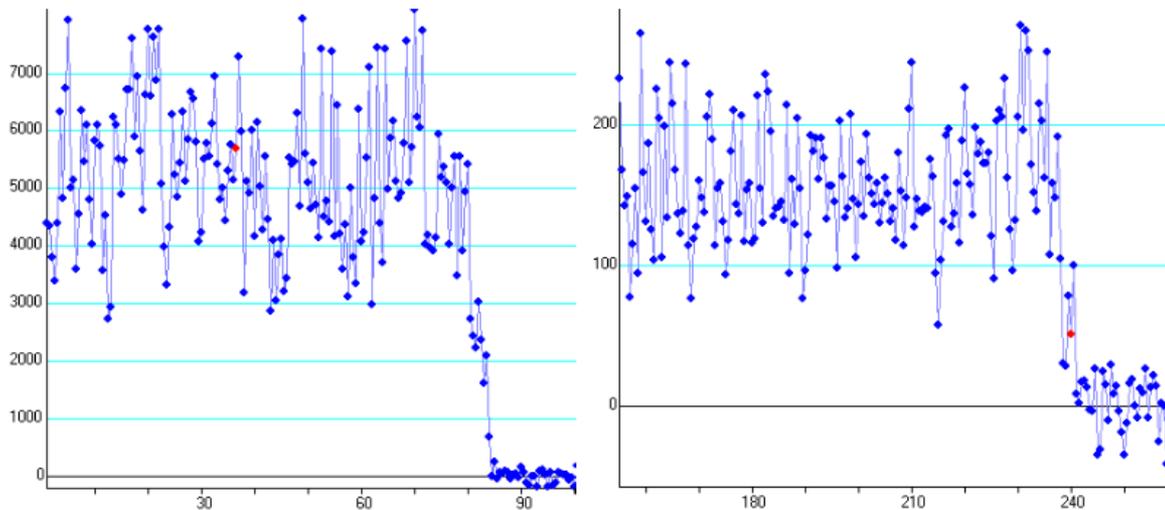
Figure 1: Light curves of Messner and Sandy on 2009 Aug 2. The step event is at a height of about 2500 on Messner's curve, and 70 on Sandy's curve.

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Lunar Occultations - Spots

Theoretical diffraction light curves for a 30-mas star lacking spots(red), and a dark spot (25%) leading (blue) and trailing (green) by 7.5-mas.

Star, spot sizes in ", Spot = 25% of star, Up,Uc = 0, Bandpass 320-720nm

FI(~xg,0.03,0.015,0.0,0.0)
FI(~xg,0.03,0.015,0.0075,~0.25)
FI(~xg,0.03,0.015,~0.0075,~0.25)

Distance on ground (meters)
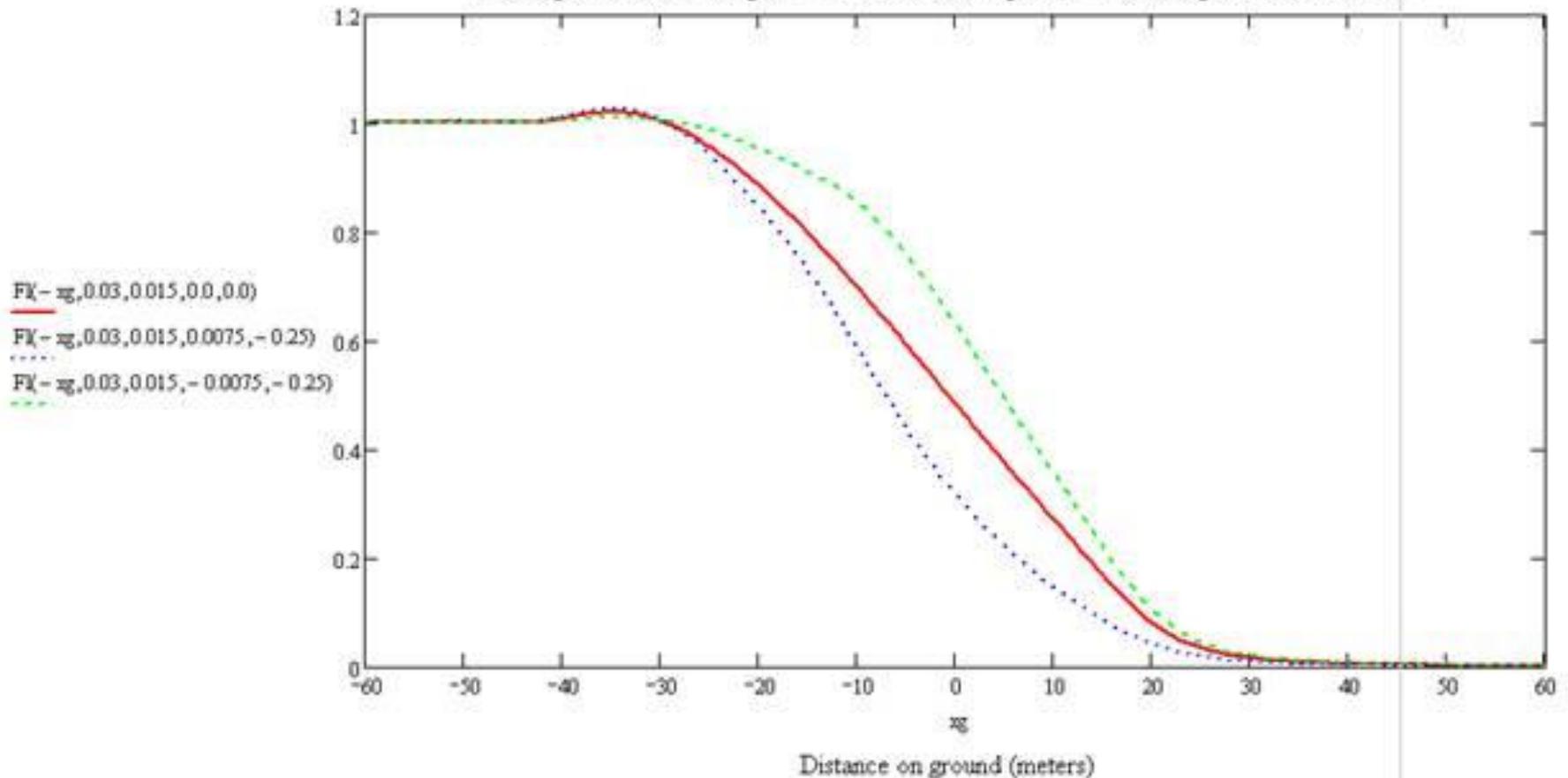
Occultations

- IOTA – focuses on timing events
- Occultation sources
  - Lunar
  - Asteroids
  - Other solar system
- KBO opportunity
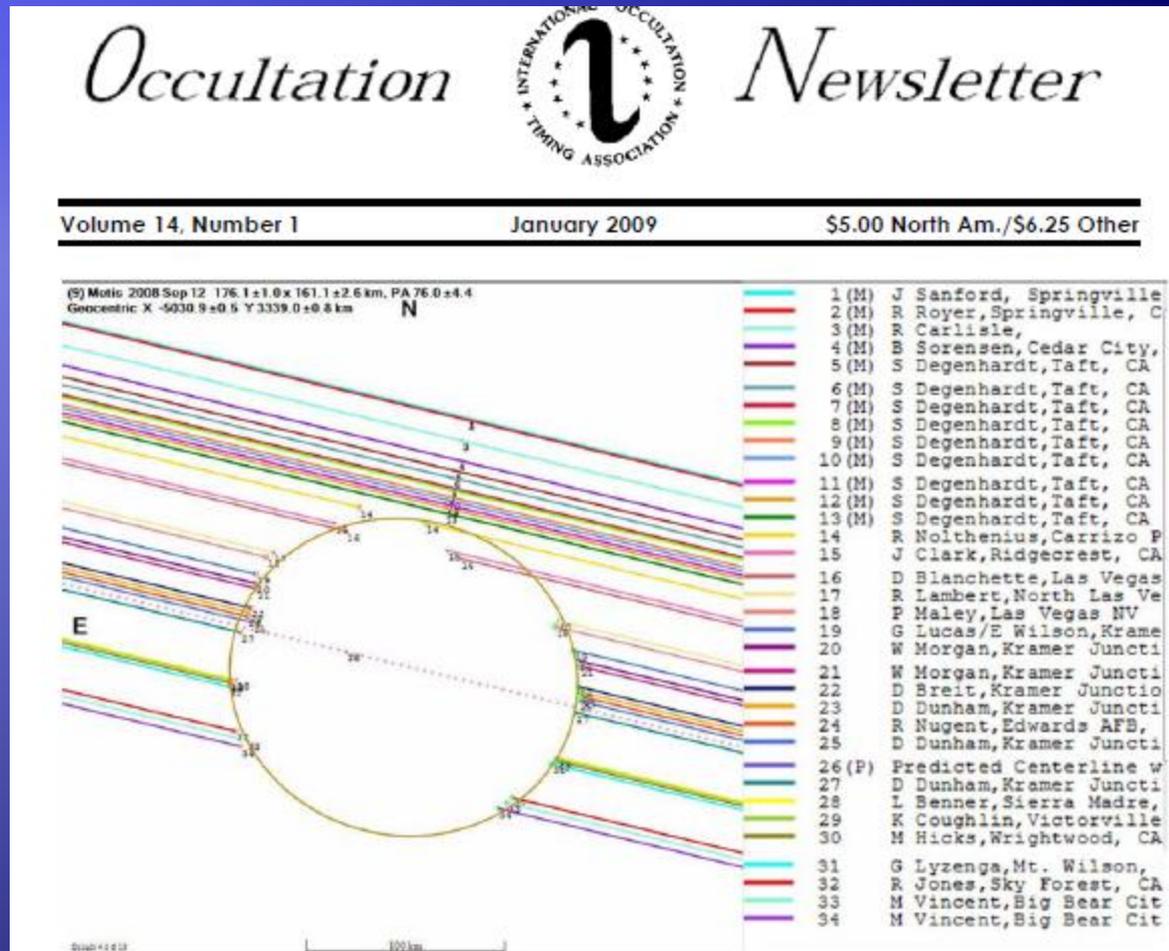
Lunar Occultations III

- IOTA Software Tools
  - Occult4, Occult Watcher, LiMovie, Tangra
  - Demo (time permitting)
- Detectors needed:
  - Fast area or diaphragm-limiting
  - Longer wavelengths (NIR) advantages

Sample Event

- Predictions based on location and elevation

Video Recording Equipment


Easycap video-to-USB

N18 on IPI 393 GEM

MDH by N18

Occultation Video

Light Curve
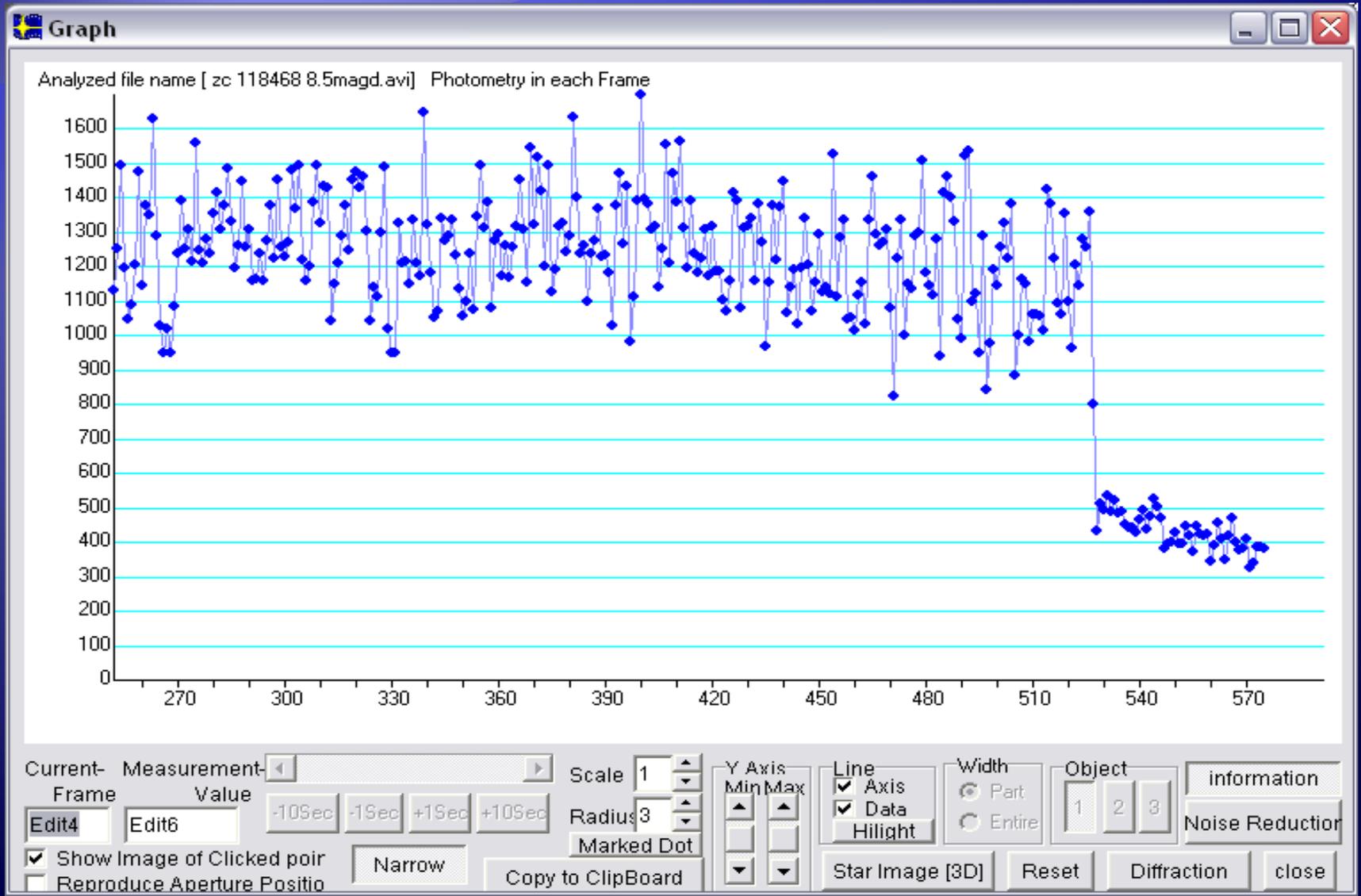
IOTA reports

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File name        : 20100618_Lunar_Bruce_Holenstein_ILOC2008.dat
Reduction date : Thursday, August 19, 2010
Ephemeris        : DE414/LE414 with DE423/LE423
Limb basis       : Kaguya {0.2deg resolution}
O-C basis        : limb correction applied

Telescopes:
 Aperture    Longitude       Latitude    Alt
#    cm        o  '   "       o  '   "     m
A    45      - 75 31 46.8    +40  3  3.4  107
B    25      - 75 31 43.7    +40  3  2.9  107
C    20      - 75 31 48.3    +40  3  0.9  107
D    20      - 75 25  1.9    +39 56 39.4  100

ref Tel Observer           Star No.      y   m   d   h   m    s     PhGrMrCeDb    O-C

001  A  G. T. 1           S 118486    2010   6 18   2 43 24.70    DD     G 1      0.01
002  A  G. T. 1           S 118468    2010   6 18   2 23 23.87    DD     G 1      0.05
003  A  G. T. 1           X  16131    2010   6 18   2 31 47.03    DD     G 1     -0.10
004  C  G. T. 1           R    560    2009  12 29   1 28 57.59    DD     G 1      0.47
005  C  G. T. 1           R    545    2009  12 29   0  5 56.81    DD     G 1      0.06

006  C  G. T. 1           R    552    2009  12 29   1  2 41.81    DD     G 1      0.03
007  C  G. T. 1           S  78452    2010   4 20   0 37 27.63    DD     G 1      0.32
008  C  G. T. 1           X  89077    2010   4 20   1  3 31.17    DD     G 1      0.30
009  C  G. T. 1           X  88834    2010   4 20   0 22 25.70    DD     G 1      0.17
010  C  G. T. 1           X  89051    2010   4 20   0 46 21.17    DD     G 1      0.35

011  D  G. T. 1           R   3370    2010   7  2   7 50  7.40    RD     G 1     -0.38
012  C  G. T. 1           S 163936    2009   9  2   0  6 18.43    DD     G 1      0.10


Explanation of columns 'PhGrMrCeDb'
Ph - Phase of the event.
     1st character D = disappear, R = reappear, B = blink, F = flash, M = Miss
     2nd character D = dark limb, B = bright limb, U = in umbra of lunar eclipse
Gr - G if the event is during a graze
Mr - Method of timing and recording. Main types are:
     G = video with time insertion, V = video with other time linking
     S = visual using a stopwatch, T = visual using a tape recorder, E = eye/ear
Ce - Certainty. 1 = certain, 2 = may be spurious, 3 = most likely spurious
Db - Double star indication - West, East, North, South, Brighter, Fainter
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Demos (time permitting)

- Time inserters, cameras, recorders
- VirtualDubMod
- Occult4
- OccultWatcher
- LiMovie
- Tangra

Contact

- Email: bholenstein@gravic.com

- Initiative Website - www.AltAzInitiative.org

- Yahoo Discussion Group - http://groups.yahoo.com/group/AltAzInitiative

More details:
The Alt-Az Initiative: Telescope, Mirror, & Instrument Developments, eds. Genet, Johnson, & Wallen, (Payson, AZ: Collins Foundation Press) 2010