LIGHT BUCKET ASTRONOMY

Lunar Occultation Theory and Practice

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

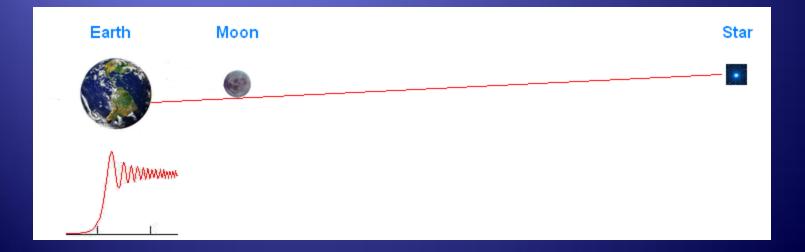


Agenda

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

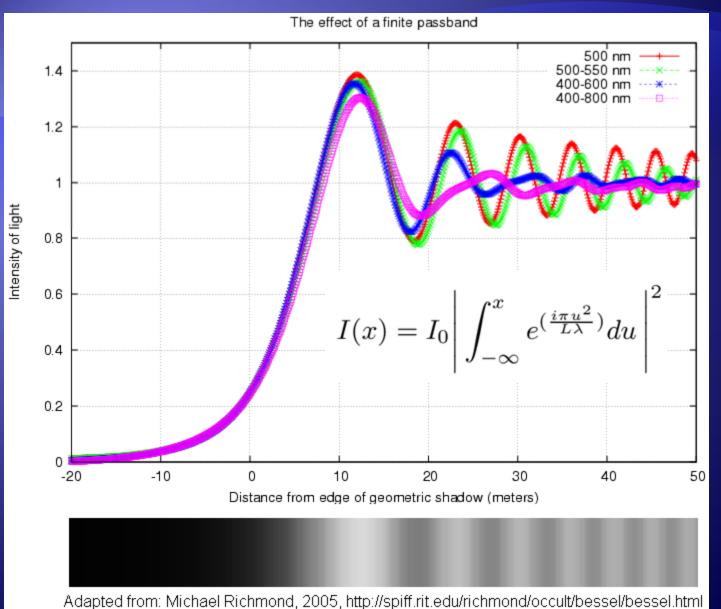
Fresnel Diffraction

- 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

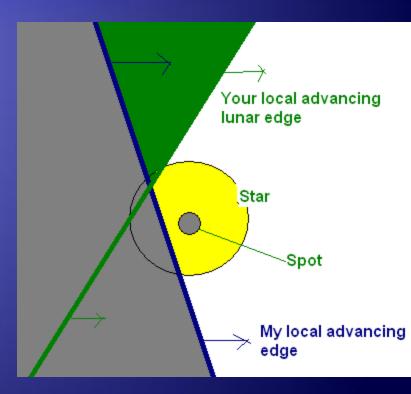
Dependencies on bandpass and geometry



4

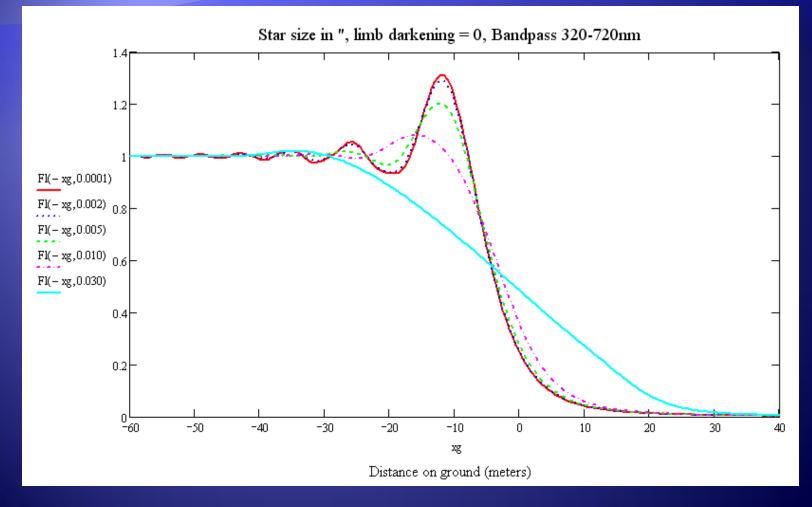
Some Occulted Object Science Potentials with a Sufficient SNR

- 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



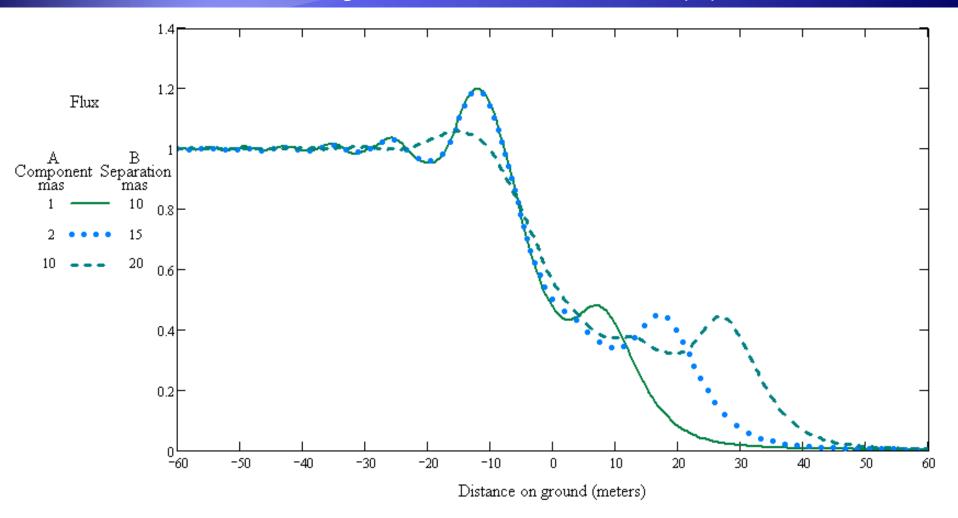
Lunar Occultations Examples

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



Lunar Occultations - Binaries

Theoretical diffraction light curves for three different binary systems



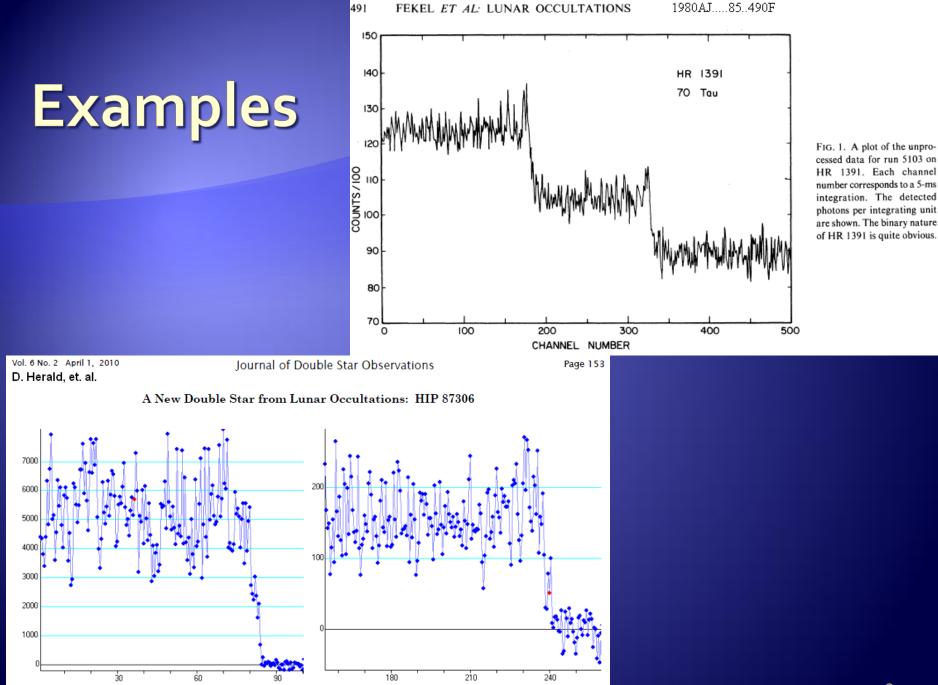
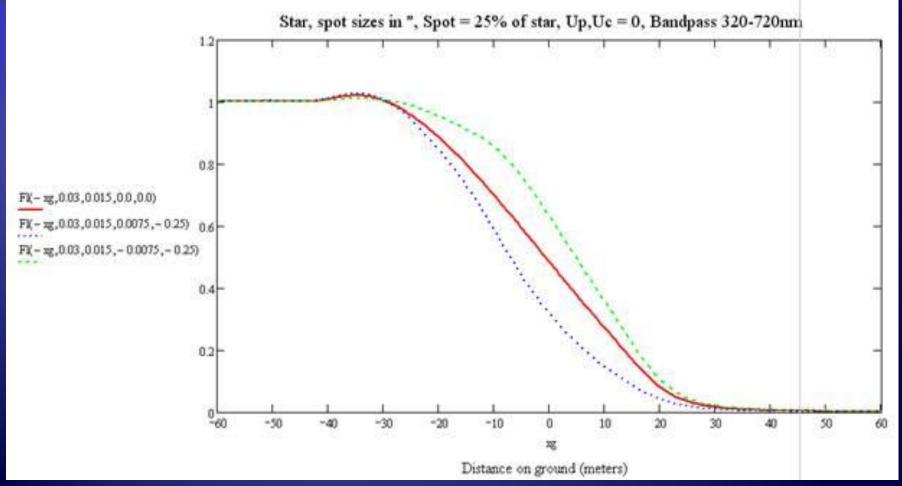


Figure 1: Light curves of Messner and Sandy on 2009 Aug 2. The step event is at a height of about 2500 on Messner's curve, and 70 on Sandy's curve.

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.

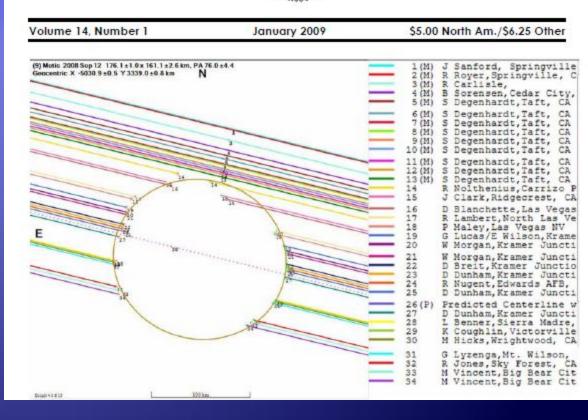


Occultations

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

Occultation





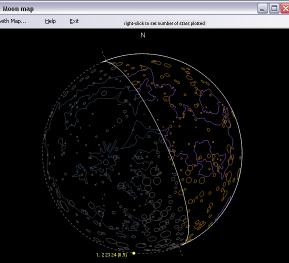
Lunar Occultations III

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

Sample Event

🖳 Lunar occultation predictions	Z
with Prediction Mag limit adjustment 🎇 3-day weather forecast 🕜 Help 🗙 Exit	
1. Select site for predictions 2. Star catalogue 3. Objects 4. Set UT dates Use home BDH sites.site ✓ ✓ Stars ✓ ✓ ✓ Stars ✓ ✓ ✓ Stars ✓ ✓ ✓ Stars ✓	6. Events anywhere Grazes Multi-site for 1 star World map
Right-click on prediction for further options Doubles only	[2010 Jun 18]
<pre>10 Jun 18 1 25 15 r X119144 11.1 10.8 37+ 75 -9 30 245 -218 225 181 203 +1.9 +6.7 +3.4+2.0 .109 -103 10 Jun 18 1 31 43 r 118445 C0 9.3 9.0 37+ 75 -10 29 246 -37N 347 302 325 +1.9 +6.7 +0.2-2.6 .346 135 10 Jun 18 1 34 13 d X 34285 K2 10.6 10.0 37+ 75 -10 29 246 79N 103 59 82 +1.9 +6.7 +0.2-2.6 .346 135 10 Jun 18 1 41 47 r X119157 11.3 11.0 37+ 75 -11 27 248 -818 285 240 264 +1.9 +6.7 +0.9-1.5 .478 -164 10 Jun 18 1 49 42 d X119272 11.5 11.0 37+ 75 26 249 79N 103 57 81 +1.9 +6.7 +0.9-1.5 .478 -164 10 Jun 18 1 51 6 d X119280 11.1 10.7 37+ 75 26 249 67N 90 44 69 +1.9 +6.7 +1.0-1.3 .432 30 10 Jun 18 2 9 48 d X119307 10.2 10.0 37+ 75 23 253 76N 100 53 79 +1.8 +6.7 +0.8-1.5 .482 20 10 Jun 18 2 11 22 r X119200 11.4 11.0 37+ 75 22 253 -718 275 227 253 +1.8 +6.7 +0.8-1.4 .466 -155 10 Jun 18 2 12 10 r 118447 K0 9.3 8.8 37+ 75 21 255 -738 277 229 255 +1.8 +6.7 +0.7-1.4 .478 -158 10 Jun 18 2 18 19 r 118452cF2 8.3 8.1 37+ 75 21 255 -738 277 229 255 +1.8 +6.7 +0.7-1.4 .479 -157 118452 is double: ** 8.5 9.1 0.10" 190.0** 118452 has been reported as non-instantaneous (OCC 412). Observations are highly desired</pre>	10 42 13.9 2 10 10 42 55.5 2 35 5 10 44 18.6 2 15 43 10 42 24.6 2 21 40 10 44 45.3 2 11 52
10 Jun 18 2 23 24 D 118468 65 8.5 8.3 371 75 20 255 298 175 127 154 +1.8 +6.7 +0.0-2.9 .293 -56	10 44 47.3 1 50 29
10 Jun 18 2 24 41 d X119309 11.5 11.2 37+ 75 20 255 615 143 95 122 +1.8 +6.7 +0.4-2.1 .478 -24	
10 Jun 18 2 31 47 d X 16131 F2 10.1 9.9 37+ 75 19 256 64N 88 39 66 +1.8 +6.7 +0.7-1.3 .450 32	Moon man
10 Jun 18 2 34 54 r X 34285 K2 10.6 10.0 37+ 75 18 257 -66N 317 269 296 +1.8 +6.8 +0.4-2.0 .504 162	10 44
10 Jun 18 2 41 49 d X119346 11.2 10.9 37+ 75 17 258 52N 76 27 54 +1.8 +6.8 +0.7-1.0 .392 43 10 Jun 18 2 43 25 d 118486 G5 9.2 8.7 37+ 75 17 258 42N 66 17 44 +1.8 +6.8 +0.8-0.7 .325 53	10 46
10 Jun 18 2 56 57 r 118468 C5 8.5 8.3 38+ 76 14 261 -385 242 193 221 +1.8 +6.8 +0.7-0.6 .307 -124	10 44
10 Jun 18 3 2 49 d X119378 11.0 10.6 38+ 76 13 261 51N 75 25 53 +1.8 +6.8 +0.5-1.0 .402 43	10 46 1
10 Jun 18 3 7 23 r X119307 10.2 10.0 38+ 76 12 263 -66N 317 268 296 +1.8 +6.8 +0.2-2.0 .521 160	10 45 :
10 Jun 18 3 18 56 r X119309 11.5 11.2 38+ 76 10 264 -708 273 223 252 +1.8 +6.8 +0.3-1.4 .515 -156	10 45 :
10 Jun 18 3 19 43 r 118486 G5 9.2 8.7 38+ 76 10 264 -34M 350 300 328 +1.8 +6.8 +0.0-2.6 .341 127	10 46
10 Jun 18 3 22 55 r X 16131 F2 F2 10.1 9.9 38+ 76 9 265 -55N 328 279 307 +1.8 +6.8 +0.1-2.1 .482 149 10 Jun 18 3 25 38 r X119346 11.2 10.9 38+ 76 9 265 -55N 328 279 307 +1.8 +6.8 +0.1-2.1 .482 149 10 Jun 18 3 25 38 r X119346 11.2 10.9 38+ 76 9 265 -44N 340 290 318 +1.8 +6.8 +0.0-2.3 .416 137	

Predictions based on location and elevation



Video Recording Equipment



Easycap video-to-¹3SB

N18 on IPI 393 GEM



MDH by N18

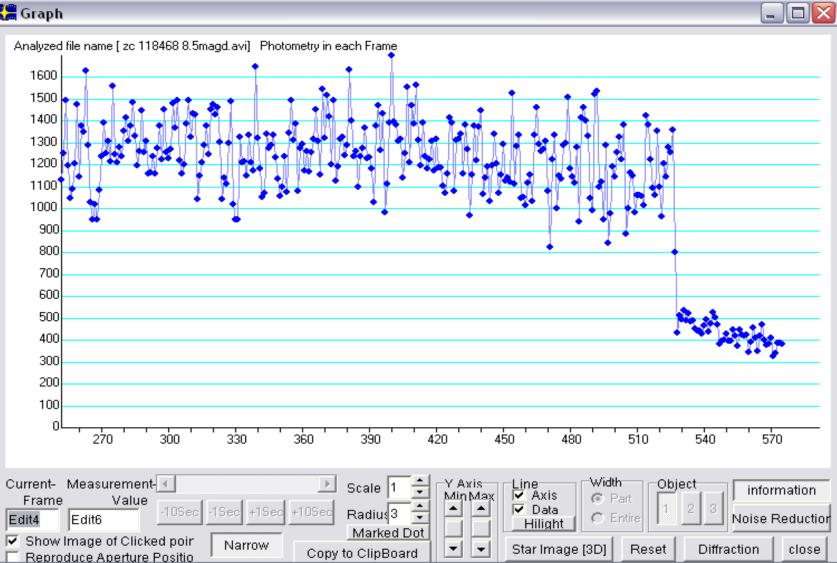
Occultation Video

C TIVi

🔚 Light Measurement Tool for Occultation Observation using Vidieo Recorder [Limovie 0.9.29b] File Edit Option Limovie File Format (for Ver.0.9.26 later) 'FileName : E:\astronomy\video\2010-06-1718 4 (075 31.7809W 40 03.0523N "Video Svstem : — , FrameRate=30.30" "Time",,,,"Centre of","End of",,,,"Result",,,,,,"Obje 06/18/10 02:23:23-00 "Detect",,"VTI",,"Frame","Frame",,,"Sound","Mea "No.","Signal1","Signal2","H","M","S",,,,"/Frame"," 252.0,"","",,,,,,1128.6,,,4.848,,,8469,94894,69,89 253.0,"","",,,,,,1251.7,,,4.359,,,8611,95138,69,89 254.0,"","",,,,,,,1491.4,,,4.667,,,8870,95388,69,89 255.0,"","",,,,,,1193.3,,,4.989,,,8560,95233,69,89 256.0,"","",,,,,,,1048.3,,,5.058,,,8409,95156,69,89 257.0,"","",,,,,,,1088.9,,,4.363,,,8449,95148,69,89 258.0,"","",......1206.6,...4.374,...8538,94777,69,89 259.0,"","",......1476.2,...5.185,...8827,95028,69,89 260.0,"","",,,,,,,1145.3,,,5.248,,,8449,94419,69,89 261.0,"","",,,,,,,1377.1,,,4.824,,,8678,94383,69,89 262.0,"","",,,,,,,1349.4,,,5.019,,,8622,94017,69,89 263.0,"","",,,,,,1627.7,,,5.205,,,8904,94065,69,89 264.0,"","",,,,,,1286.5,,,4.914,,,8514,93434,69,89 265.0,"","",,,,,,,1025.9,,,4.491,,,8263,93558,69,89 266.0,"","",,,,,,,949.7,,,4.688,,,8180,93470,69,892 267.0,"","",......1019.8,...4.496,...8234,93262,69,89 268.0,"","",,,,,,951.1,,,4.577,,,8188,93555,69,892 269.0,"","",,,,,,,1082.6,,,4.668,,,8313,93472,69,85 < 111 > Gamma Reverse Correction 1.00 More End Time of Field Exposure (Field1=Centre of Frame) h m s [Field1] [Field2] Threshold S1 S2 80 🗧 🔽 KIWI Audio Channel Display Star Image [3D] Current Frame 4 . Measurement File E:\astronomy\video\2010-06-1718 4 c START STOP DataRemove SaveToCSV-File 523 1Frame DEL 144 -1Fr 1Fr+ 1sec+ 10sec+ -10sec -1sec 4 AVI File Open Load CSV Exit Measurement Value Linked Tracking Speed Control Form of BKG-Area Number of Pixels / Radius Position Link Passed Frame1 Frame2 Center Tracking Standard BKG/Frame 71.6 Aperture Backgound X= 300 Measurement / View Option 300 Frame Rate Avoid Sunlit Face Even 32 446 Point Set Clr Set Clr Star Even 463.1 0 Delay (Sec) 1.0 Interval from VFW Field Show Y= 179 179 Meteor/Lunar Limb 37 Odd 446 Passed Point (Frame.) Star Tracking Field Measure 🐥 30.30 Sync-APT Half Flux Position Set Odd 436.6 Direction Setting Frame 69 892 Star Diameter 6 Anchor Frame2 Radius Inner Outer Radius Threshold Field Order Current Object Frame 899.6 Width Gap Signal1 · Drift 4 25 C Even first Signal2 10 4.888 Set Clr Set Clr 25 Graph 50 0 1 -OFF Color Value · Odd first

Light Curve

🔚 Graph



IOTA reports

File name : 20100618_Lunar_Bruce_Holenstein_IL0C2008.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						
<i>"</i>	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.	. ул	m d h	m s	PhGrMrCeDb (0-C		
001 A G. T. 1 S 118486	5 2010 é	6182	43 24.70	DD G1 (0.01		
002 A G. T. 1 S 118468					0.05		
003 A G. T. 1 X 16133					0.10		
004 C G. T. 1 R 560					0.47		
005 C G. T. 1 R 54					0.06		
005 C G. I. I K 343	5 2003 12	2 23 0	3 30.01		5.00		
006 C G. T. 1 R 552	2 2009 12	2 29 1	2 41.81	DD G1 (0.03		
007 C G. T. 1 S 78452	2 2010 4	4200	37 27.63	DD G1 (0.32		
008 C G. T. 1 X 8907	7 2010 4	4201	3 31.17	DD G1 (0.30		
009 C G. T. 1 X 88834	i 2010 4	4200	22 25.70	DD G1 (0.17		
010 C G. T. 1 X 8905	L 2010 4	4200	46 21.17	DD G1 (0.35		
011 D G. T. 1 R 337(50 7.40		0.38		
012 C G. T. 1 S 163936	5 2009 9	920	6 18.43	DD G1 (0.10		
Explanation of columns 'PhGrMrCeDb' Ph - Phase of the event. lst 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. l = certain, 2 = may be spurious, 3 = most likely spurious Db - Double star indication - West, East, North, South, Brighter, Fainter							
DD Downle scal indicacion - west, Bast, Morth, South, Brighter, Fainter							

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Demos (time permitting)

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

Contact

Email: <u>bholenstein@gravic.com</u>

- Initiative Website www.AltAzInitiative.org
- Yahoo Discussion Group -<u>http://groups.yahoo.com/group/AltAzInitiative</u>

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