

# Photographing the Full Moon

## Sun and Moon Basics

### Terminology

- *Rise/Set*—time at which a celestial body's *upper limb* is on the horizon
- *Azimuth*—angle with north; equivalent to compass bearing
  - Range: 0–360°
  - True north vs. magnetic north
- *Altitude*—angle above horizon
  - Range:  $\pm 90^\circ$

### Terminology

- *Declination*—angle between a body's position and the plane of the equator
  - Range:  $\pm 90^\circ$
- *Age*—of the moon—time, in days, since last new moon
  - Range: 0–29.53 days
- *Phase*—fraction of moon's surface illuminated
  - New moon: 0
  - Quarter moon: 0.5
  - Full moon: 1

### Earth's Orbit

- Period: 365.25 days
- Earth–sun distance
  - Mean:  $150 \times 10^6$  km
  - Range:  $147 \times 10^6$  km– $152 \times 10^6$  km
  - Light intensity, max/min: +0.1 EV
- Sun's declination:  $\pm 23^\circ 26'$ ; affects
  - Length of day
  - Maximum solar altitude
  - Rise and set azimuths

### Moon's Orbit

- New-to-new (synodic month): 29.53-day cycle
- Inclination to earth's orbit about sun:  $5^\circ$ 
  - Maximum declination varies:  $\pm 18.5^\circ$  to  $\pm 28.5^\circ$ , over 18.6-year cycle
- Phases and approximate dates repeat every 19 years (Metonic cycle)
- Opportunities seldom repeat . . .

**Moon Size vs. Distance**

- Earth–moon distance
  - Mean: 384,400 km
  - Range: 356,000 km–407,000 km
- Angular diameter
  - Mean: 0.52°
  - Range: 0.49°–0.56°
  - Max/min: 1.143

**Time of Moonrise and Moonset**

- Moon rises and sets 49 minutes later each day (on average)
- New moon rises and sets with sun
- Waxing moon rises during daylight and sets after dark
- Full moon rises at sunset and sets at sunrise
- Waning moon rises after dark and sets during daylight

**Twilight Sky Lighting**

- Twilight arch
  - Yellow-orange glow around setting sun
- Antitwilight arch
  - Pink glow opposite setting sun
- Earth shadow
  - Blue band rising under pink antitwilight arch

**Twilight Arch**

- Bright yellow-orange from sunset to approximately 30 minutes after sunset
- Broad, diffuse light source for windows in foreground
- Gives shadowless alpenglow

**Antitwilight Arch and Earth Shadow**

- Pink glow lasts from 15–20 minutes before sunset to about 30 minutes after sunset
- Pink above blue an attractive element of twilight moon photographs
- Pink–boundary
  - Most pronounced from sunset to about 10 minutes after sunset
  - More pronounced at higher altitudes

## **Planning the Shot**

### **Using a Map**

- Paper
  - USGS topographical map
  - DeLorme atlas
- Computer
  - DeLorme Topo USA or TopoQuads
  - Maptech Terrain Navigator or Terrain Navigator Pro
  - National Geographic (formerly Wildflower) TOPO!

### **Field Measurements**

- Azimuth: compass or transit
  - Magnetic declination
- Altitude: clinometer or transit
- Time: watch
  - Synchronize with time standard
  - Synchronize camera if appropriate
- Location: map or GPS
- Notes: audio recorder
- Location scouting photograph

### **Location Scouting Photographs**

- Get a wide-angle view
- Ideally, record:
  - Latitude and longitude—GPS is helpful
  - Azimuth of lens axis
  - Altitude of horizon (if not level) and other key features
  - Lens focal length or zoom setting

### **Planning—Two Approaches**

- Date priority
- Location priority

### **Date Priority**

- Choose a suitable date
- Determine the azimuth of rise or set
- Find a suitable location and foreground

### Choosing a Suitable Date

San Francisco, CA								
Day	Date	M Rise	S Set	Diff	Az MR	Az SS	M Age	Phase
Mon	7-22-2002	19:38	20:27	-0:49	122.5	296.4	13.5	0.982+
Tue	7-23-2002	20:28	20:26	+0:02	120.9	296.2	14.5	0.999+
Wed	8-21-2002	19:46	19:55	-0:09	114.8	285.7	14.0	0.992+
Thu	8-22-2002	20:18	19:53	+0:24	109.6	285.2	15.0	0.998-
Thu	9-19-2002	18:49	19:11	-0:22	105.8	272.1	13.4	0.977+
<b>Fri</b>	<b>9-20-2002</b>	<b>19:15</b>	<b>19:10</b>	<b>+0:05</b>	<b>99.6</b>	<b>271.6</b>	<b>14.3</b>	<b>0.996+</b>
Sat	10-19-2002	18:07	18:27	-0:20	88.7	257.6	13.6	0.985+
Sun	10-20-2002	18:31	18:25	+0:05	82.2	257.2	14.5	0.998+
Tue	11-19-2002	16:55	16:56	-0:01	66.5	245.5	14.7	1.000+
Wed	11-20-2002	17:30	16:55	+0:35	61.9	245.2	15.7	0.991-
Thu	12-19-2002	16:53	16:53	-0:00	57.2	245.0	15.0	0.999-
Fri	12-20-2002	17:48	16:54	+0:54	56.8	245.0	16.0	0.982-

### Finding a Location: Moon Position vs. Features

Lincoln@Long (SF) (Fri 9-20-2002 (PDT): Sunset 19:10; Moonrise 19:15 @ 100.0)										
	Dist	Az	Alt	M Az	M Alt	EV <sub>m</sub>	EV <sub>sk</sub>	EV Diff	Time	T <sub>ss</sub>
Russian Hill	3.10	100.3	0.84	100.2	0.60	10.34	10.33	0.01	19:20	+10
Bellaire Tower	2.92	100.5	1.77	100.6	0.93	9.52	9.50	0.02	19:22	+12
				100.7	1.10	9.06	9.02	0.04	19:23	+13
				100.8	1.27	8.62	8.53	0.09	19:24	+14
				101.0	1.45	8.22	8.04	0.18	19:25	+15
				101.1	1.62	7.89	7.57	0.32	19:26	+16
				101.3	1.79	7.68	7.12	0.56	19:27	+17
Transamerica Building	3.75	<b>101.4</b>	<b>1.68</b>	<b>101.4</b>	<b>1.97</b>	7.58	6.70	0.88	19:28	+18
Transamerica spire	3.75	<b>101.4</b>	<b>2.30</b>							
50 California	4.07	101.6	1.14	101.6	2.15	7.59	6.29	1.30	19:29	+19

### Location Priority—General

- Be prepared—know times and azimuths of rise and set, and preferably, moon positions throughout the day
- Use a compass and a clinometer, to anticipate the moon's position in a scene

### Use Reliable Values for Times And Rise/Set Azimuths

- Day-to-day changes in moon rise/set times aren't constant
- Day-to-day changes in moon rise/set azimuths aren't constant
- Use published or calculated values

### Location Priority: Specific Composition

- Quick check: see if the scene is within the range of the moon's rise or set azimuths
- Make a scouting photograph
- Determine the azimuth and altitude of the desired moon position
- Determine whether the moon ever will appear in that position at the desired time

## Exposure

### Two Types of Moon Photography

- Astrophotography
  - Moon the primary (or only) element
  - Photographed through a telescope
  - Moon far above horizon
- Landscape photography
  - Moon a small (though significant) element
  - Photographed with a camera lens
  - Moon close to horizon

### Popular Exposure “Rules”

- Some apply to astrophotography
  - Kodak P-150
- Some don't really apply
  - “Sunny 16” (EV 14.6) [Nikon School]
  - “Loony 11” (EV 13.6) [John Shaw?, many others]
  - 250 cd/ft<sup>2</sup> placed on Zone VII (EV 12.4) [Ansel Adams]

### Moon Lighting

- “It's always daylight on the moon”
- Illuminance on moon's surface is relatively constant
- Moon luminance (seen from earth) varies considerably

### Moon Luminance

- Varies with phase because of changes in moon's reflectance
- Varies with lunar altitude because of absorption by earth's atmosphere
- Combines with sky luminance
- *Independent* of foreground luminance

### Three Different Conditions

- Daytime
  - Normal landscape—expose for the foreground
- Twilight
  - Expose for the sky—use spot or partial-area metering
  - Watch moon–sky contrast
- Night
  - Expose for the moon (foreground silhouette)
  - Use a long lens—or a telescope . . .

**Simplified Zone System: B & W Film**

Zone	Characteristic
0	Pure black
III	Darkest tone with detail
V	Medium tone
VII	Lightest tone with detail
IX	Pure white

**Zone–Exposure Compensation Equivalence**

Zone	Compensation
II	–3
III	–2
IV	–1
V	<b>0</b>
VI	+1
VII	+2
VIII	+3

**“Proper” Rendering**

- Moon
  - Perceived, near horizon: Zone V
  - Perceived, 7°: Zone VI
  - Maximum to hold detail: Zone VII
- Sky
  - At sunset: Zone V to Zone VI
  - Sunset + 20 minutes: Zone IV

**Metering the Moon is Difficult**

- Moon’s angular diameter is 0.52°
- Moon image ~ 5.4 mm (2.7% of 35 mm frame) with 600 mm lens
- Ordinary handheld spot meters are 1°
- Specialized luminance photometers (e.g., Minolta LS-110) are expensive and awkward to use

**Metering Options**

- Lens long enough to cover spot area with moon
  - Use in-camera meter
- Shorter lens
  - Use in-camera meter and adjust for assumed difference in metered area
  - Test on full moon against clear, dark sky at high altitude
  - Only works if moon substantially brighter than sky
- Handheld spot meter
  - Same as for shorter lens

### Balance Moon and Landscape

- Choose the best day
- Graduated ND filters
- Digital composite: one for moon, one for foreground

### Choosing the Best Day

- For moonrise above level horizon, usually when moon rise/set is within a few minutes of sun set/rise
  - Earlier moon rise better for natural landscapes
  - Later moon rise sometimes better for cityscapes
  - Usually day of full moon or day before
- For horizon with tall buildings or mountains
  - Can be several days before full moon for rise
  - Can be several days after full moon for set

### Moonrise vs. Sunset

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### Moon is a Moving Target

- Moon moves 40% of its diameter per minute
- Longest recommended exposure:
  - For 100 mm lens on 35 mm camera: 2.5–5 s
  - For 500 mm lens on 35 mm camera: 0.5–1 s

### Summary—Planning

- Know time and azimuth of moon rise or set
- Identify potential locations in advance
- If possible, scout potential locations
- Pick a time when the moon is *where* you want it *when* you want it there

### Summary—Exposure

- Pick the right day to manage contrast
- In most cases, expose for the sky or foreground—remember, it's a *landscape* that happens to include the moon
- Forget the popular exposure “rules”

### Resources

#### Times and Positions

- Newspaper (rise and set times)
- *The Old Farmer's Almanac* [www.almanac.com](http://www.almanac.com)  
Rise and set times for the sun and moon, tide information, and some entertaining facts and articles. Handy if you can't get on the net and can't find a newspaper that gives the times for your location. Northern California residents should get the Western Edition, which lists times for San Francisco.
- *Outdoor Photographer* (rise and set azimuths) [www.outdoorphotographer.com](http://www.outdoorphotographer.com)
- US Naval Observatory web site [www.usno.navy.mil](http://www.usno.navy.mil)  
Rise and set time for the sun and moon, dates and times of solar and lunar eclipses, and much more. The most authoritative source available.
- Astronomy software

#### Astronomy Software

- Bruce Sidell [www.moonrise.us](http://www.moonrise.us)  
— Moonrise (Windows 9x/Me/2000/XP)
- Willmann-Bell [www.willbell.com](http://www.willbell.com)  
— U.S Naval Observatory MICA (PC & Mac)

#### Astronomy Calculation Books

- Montenbruck, Oliver, and Pfleger, Thomas. *Astronomy on the Personal Computer*. 4th ed. Berlin: Springer-Verlag, 2000  
Includes a CD-ROM with the example programs in C++.
- Meeus, Jean. *Astronomical Algorithms*. 2nd ed. Richmond: Willmann-Bell, 1999  
A comprehensive collection of algorithms and computational techniques for the amateur astronomer, with emphasis on computation rather than explanation. A companion diskette with BASIC, Pascal, or C source code for many algorithms was available with the first edition; unfortunately, the diskette is not available with the second edition.
- Duffett-Smith, Peter. *Practical Astronomy with Your Calculator*. 3rd ed. Cambridge: Cambridge University Press, 1988  
Although the calculator is no longer the engine of choice for computational astronomy, this book gives concise explanations of several concepts that the other works omit.
- Duffett-Smith, Peter. *Easy PC Astronomy*. Cambridge: Cambridge University Press, 1996  
Includes a scripting language (AstroScript) interpreter to simplify many astronomical computations.

### Photography Books

- Adams, Ansel. *Natural Light Photography*. Book 4 of the Ansel Adams Basic Photo Series. Boston: New York Graphic Society, 1952.  
Long out of print, it's still worth reading if a used copy can be located. Except for suggesting the use of a constant average value for the moon's luminance, the chapter on "The Moon and Moonlight" the treatment is still definitive.
- Adams, Ansel. *The Negative*. Book 2 of The New Ansel Adams Photography Series. Boston: New York Graphic Society, 1981.  
Many books have been written on the Zone System; this is a good introduction.
- Petersen, Bryan F. *Understanding Exposure*. New York: AMPHOTO, 1990

### Moon photographs

- Flaherty, Dennis. *Mono Lake: Mirror of Imagination*. Santa Barbara: Companion Press, 1996  
Exquisite large-format images of Mono Lake and the surrounding area, including a few of the moon in different seasons from various locations around the lake.
- Rigler, James. *San Francisco Moon*. Berkeley: Celestial Arts, 1998  
Photographs of the moon over San Francisco from a wide variety of locations.
- Larsen, Frederic (SF Chronicle). [www.SFGate.com/buyphotos](http://www.SFGate.com/buyphotos)  
An award-winning photojournalist, Larsen also excels in photographs of the moon against well-known San Francisco landmarks.

### Moonrise, Hernandez, NM

- Adams, Ansel. *Examples: The Making of 40 Photographs*. Boston: Little, Brown, and Company, 1983.  
The making of this striking photograph is described here, as well as in *The Negative*.
- Callahan, Sean. "Short Takes: Countdown to Moonrise," *American Photographer*, January 1981.  
Adams neglected to record the date on which he made his most famous image. At the request of photo historian Beaumont Newhall, David Elmore of the High Altitude Observatory in Boulder, Colorado, visiting the site of the photograph, and after making a few calculations, concluded that the photograph was taken on 31 October 1941 at 4:03 P.M.
- diCicco, Dennis. "Dating Ansel Adams' Moonrise," *Sky & Telescope*, November 1991  
After reading Sean Callahan's article in *American Photographer*, diCicco calculated the moon's position for the proposed time and date, and noticed that the position didn't match the photograph. Supported by painstaking field measurements with a surveyor's transit, and aided by computing power barely imagined in 1980, diCicco determined that the photograph actually was taken on 1 November 1941 at 4:49:20 P.M.

### Mapping Software

- National Geographic [www.nationalgeographic.com/maps/](http://www.nationalgeographic.com/maps/)
- Delorme [www.delorme.com](http://www.delorme.com)
- Maptech [www.maptech.com](http://www.maptech.com)

**Compasses & Clinometers**

- Resellers
  - REI: [www.rei.com](http://www.rei.com)
  - Wide-Screen Software: [www.wide-screen.com](http://www.wide-screen.com)  
California cinematographer David Parrish developed SunPATH software to assist in his own work; he also sells Suunto compasses and clinometers.
- Manufacturers
  - Brunton: [www.brunton.com](http://www.brunton.com)
  - Silva: [www.silva.se](http://www.silva.se)
  - Suunto: [www.suunto.com](http://www.suunto.com)

**Magnetic Field Calculation Software**

- Interpex [www.interpex.com](http://www.interpex.com)
  - Geomagix (Windows 9x/NT)
- Resurgent Software [www.resurgentsoftware.com/geomag.html](http://www.resurgentsoftware.com/geomag.html)
  - GeoMag (Windows 98/2000/XP)
- NOAA Satellite and Information Services—Geomagnetism  
[www.ngdc.noaa.gov/seg/potfld/geomag.shtml](http://www.ngdc.noaa.gov/seg/potfld/geomag.shtml)  
Provides online calculation of magnetic declination; free geomagnetic software (source and executables) is available for download.