



The Astronomical League

A Federation of Astronomical Societies

Astro Note F1 – Astrophotography 1:

Star Trails

Introduction – The Earth's rotation makes the stars appear to move from east to west in the sky. For a stationary, unguided camera of focal length F , a star having declination δ , will photograph as a trail of linear length, L , in an exposure time of t seconds:

$$L = \frac{t * F * \cos(\delta)}{13750}$$

Note that the units of length, L , will be the same as the units of F .

Shorter exposures will result in shorter trail lengths. Assuming an 8x enlargement of a print and "normal" viewing distances, a trail of 0.1 mm or less will be virtually unnoticeable. The following table indicates maximum unguided exposures which will meet this criterion with several common 35 mm camera lenses (for a full-frame sensor, smaller sensors will be less):

maximum exposure in seconds at declination (+ or -)

lens focal length	35mm field	0°	30°	45°	60°
28mm	49 x 73	49	56	70*	98*
35mm	39 x 59	39	45	55	78*
50mm	25x 37	36	31	37	5
100mm	14 x 21	14	16	20	28
135mm	10 x 15	10	12	14	20
200mm	7 x 10	7	8	10	14
300mm	4.6 x 7	4.6	5.3	6.5	9
400mm	3.5 x 5	3.5	4	5	7

***Note:** exposures over 60 seconds with "fast" lenses (f/2 or better) will be more likely to show brighter sky fog.

The angle of sky coverage, β , of any film having linear dimension s used with a lens of focal length F is given by (s and F must have the same units):

$$\beta = 2 * \tan^{-1}\left(\frac{s}{2 * F}\right)$$

Instrument Requirements for Various Objects:

Object Type	Lens	Lens/Telescope Focal Length	f/ratio	Comments
Star Trails	as available	50mm-400mm	f/2.8–f/8	f/4 lens having 40° coverage best
Moon	telescope	50" or greater; use amplification	f/8–f/80	35mm SLR on telescope with projection
Sun	telescope	same as Moon	same as Moon	Use proper filters to avoid eye and equipment damage
Planets	telescope	100" or greater	f/16–f/25	Projection necessary to enlarge image
Stars (general)	25mm diameter minimum	Any, but 100mm-300mm best	f/4 – f/8	Use medium speed f/ for best definition
Star Clusters	50mm diameter minimum for open clusters	400mm or longer	f/4–f/16	Use longer focus for smaller clusters
Nebulae	50mm diameter minimum	150mm lens or short focus telescopes	f/2–f/8	Need greatest possible light collection
Comets	25mm diameter minimum	100mm lens or short focus telescopes	f/2–f/5.6	Wide angle for tail coverage; long focal length for coma
Aurora	25mm diameter minimum, fast	28mm-100mm	Wide open, f/2–f/4	Wide angle; short exposures to minimize motion
Meteors and Satellites	As available	50mm-100mm	f/2–f/4	40° - 60° sky coverage