Extreme photography

CS 178, Spring 2011

Marc Levoy
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Stanford University

Extremes

- ✦ high resolution
- high speed
- low speed
- small aperture
- large aperture
- narrow field of view
- wide field of view
- high dynamic range
- low dynamic range

Sinar view camera
10,000 × 8,000 pixels

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CRAYONS
Different Brilliant Colors
TOYS"R"US
68 17 F
PRICE
X>X<$2.57

© Marc Levoy

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111-megapixel wafer-scale sensor

- 95mm × 95mm CCD sensor
- 10,580 × 10,560 pixels
- low yield, very expensive

5” (aperture) telescope at the U.S. naval observatory, Flagstaff, AZ

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Graham Flint's gigapxl.org

- custom camera and lens
- 18" negative → drum scanner → printer
- 40,000 pixels × 25,000 pixels

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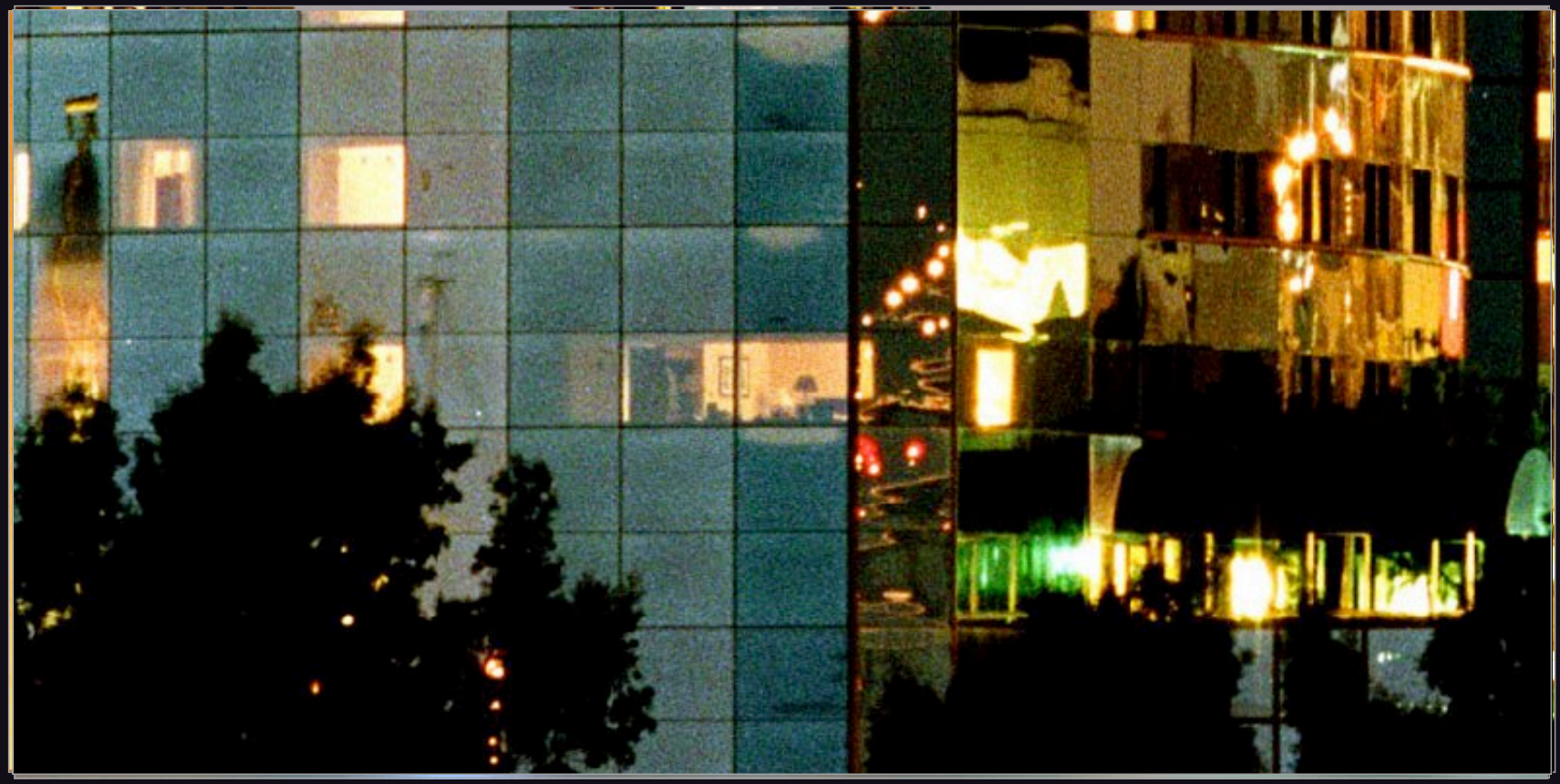
Balboa Park, San Diego

(full-resolution print in Gates Hall, 3rd floor, entrance to graphics wing)



San Diego Skyline

xrez.com (also gigapixel resolution)

© Marc Levoy

xrez.com (also gigapixel resolution)

© Marc Levoy

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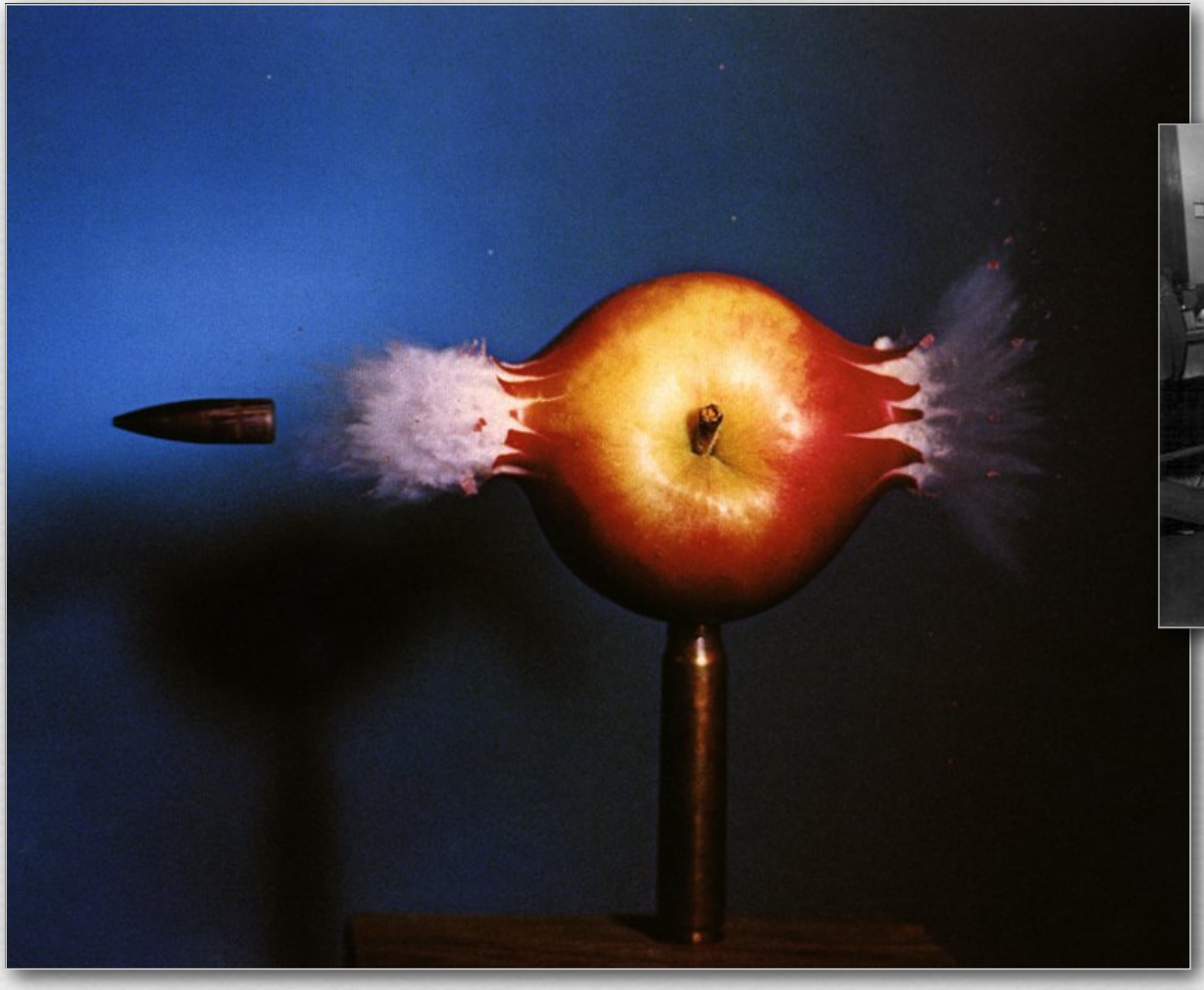
Harold Edgerton:

"father" of high-speed photography



from Stopping Time, 1964

- no shutter
- electronic strobe
- microphone near gun

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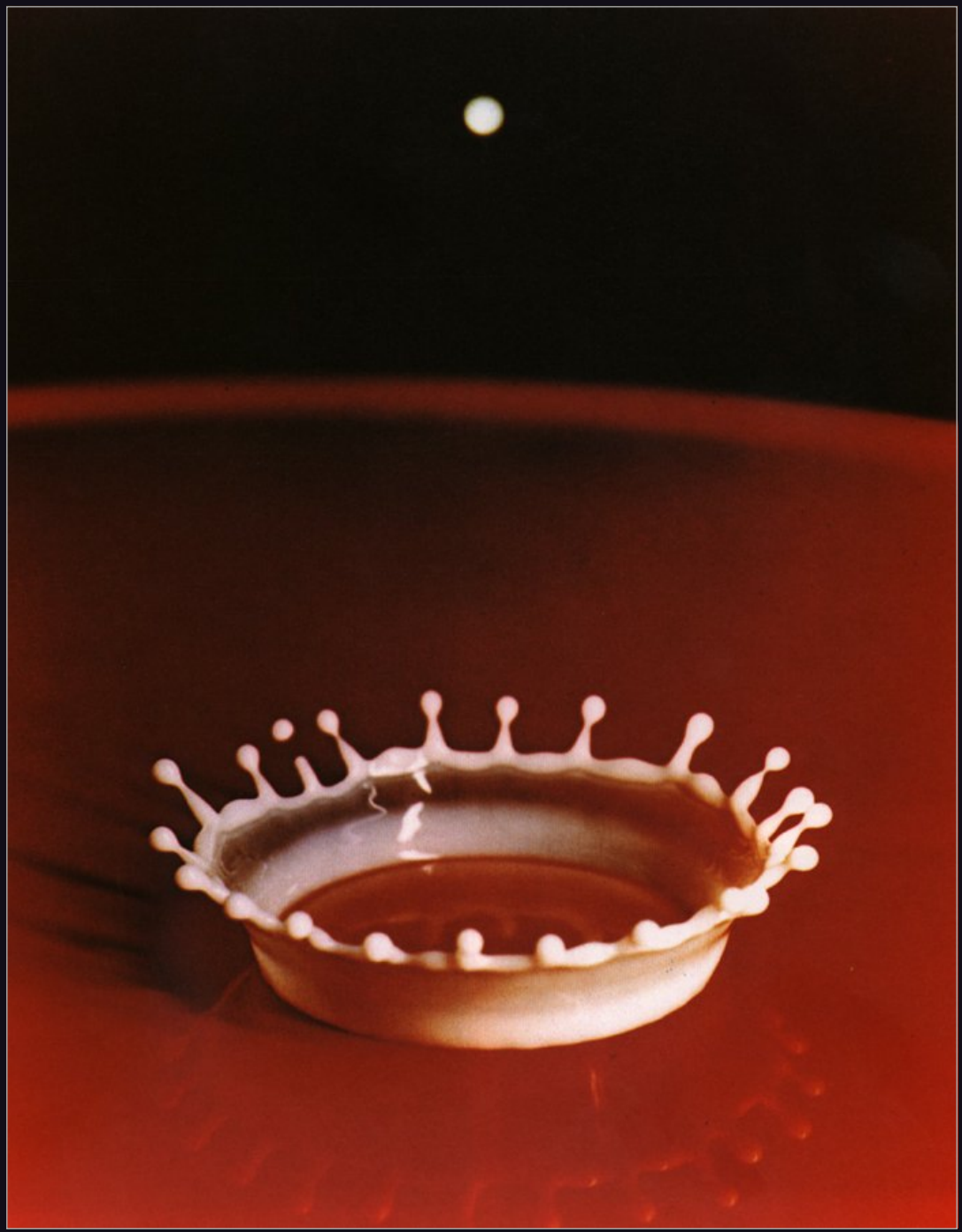
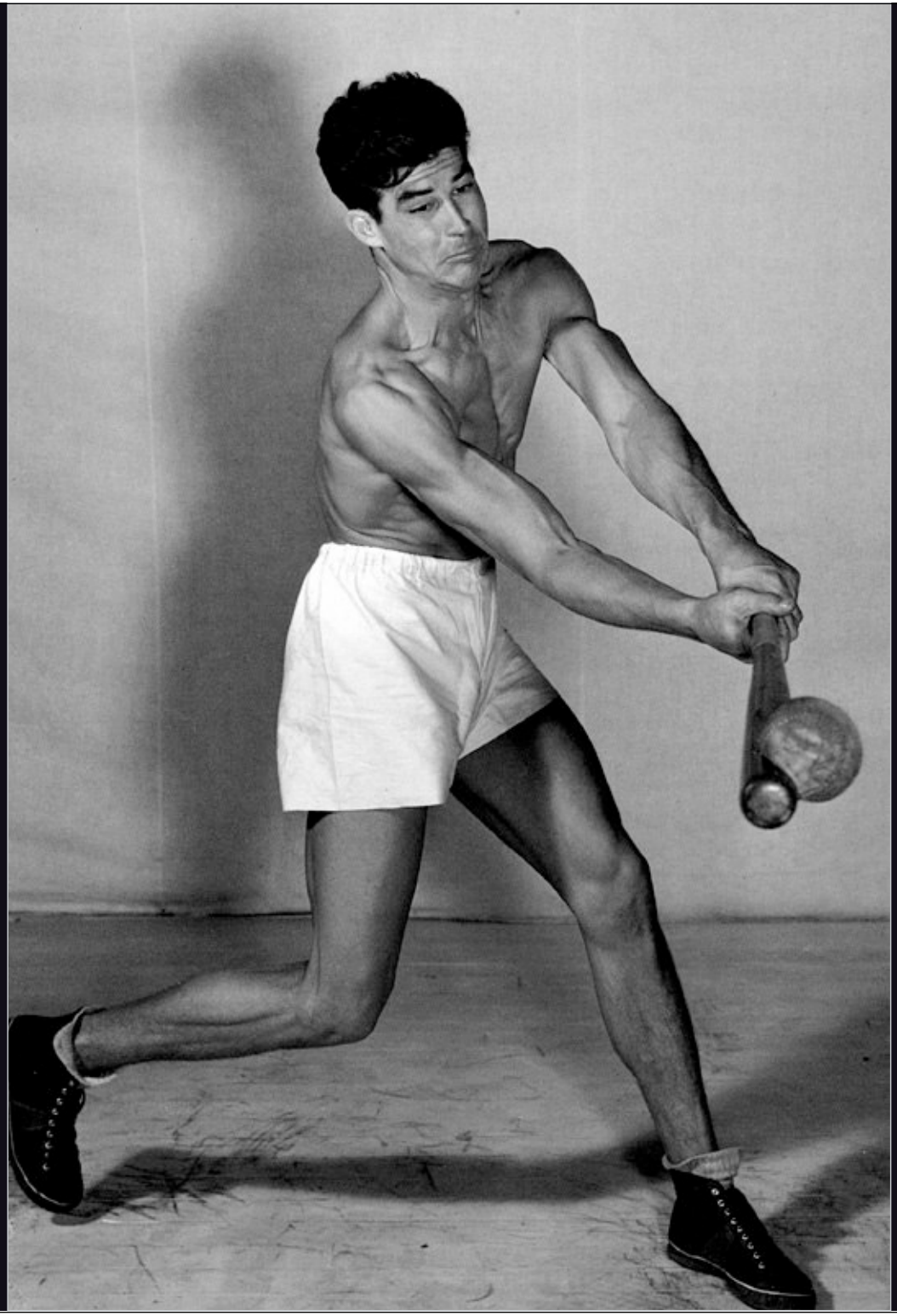
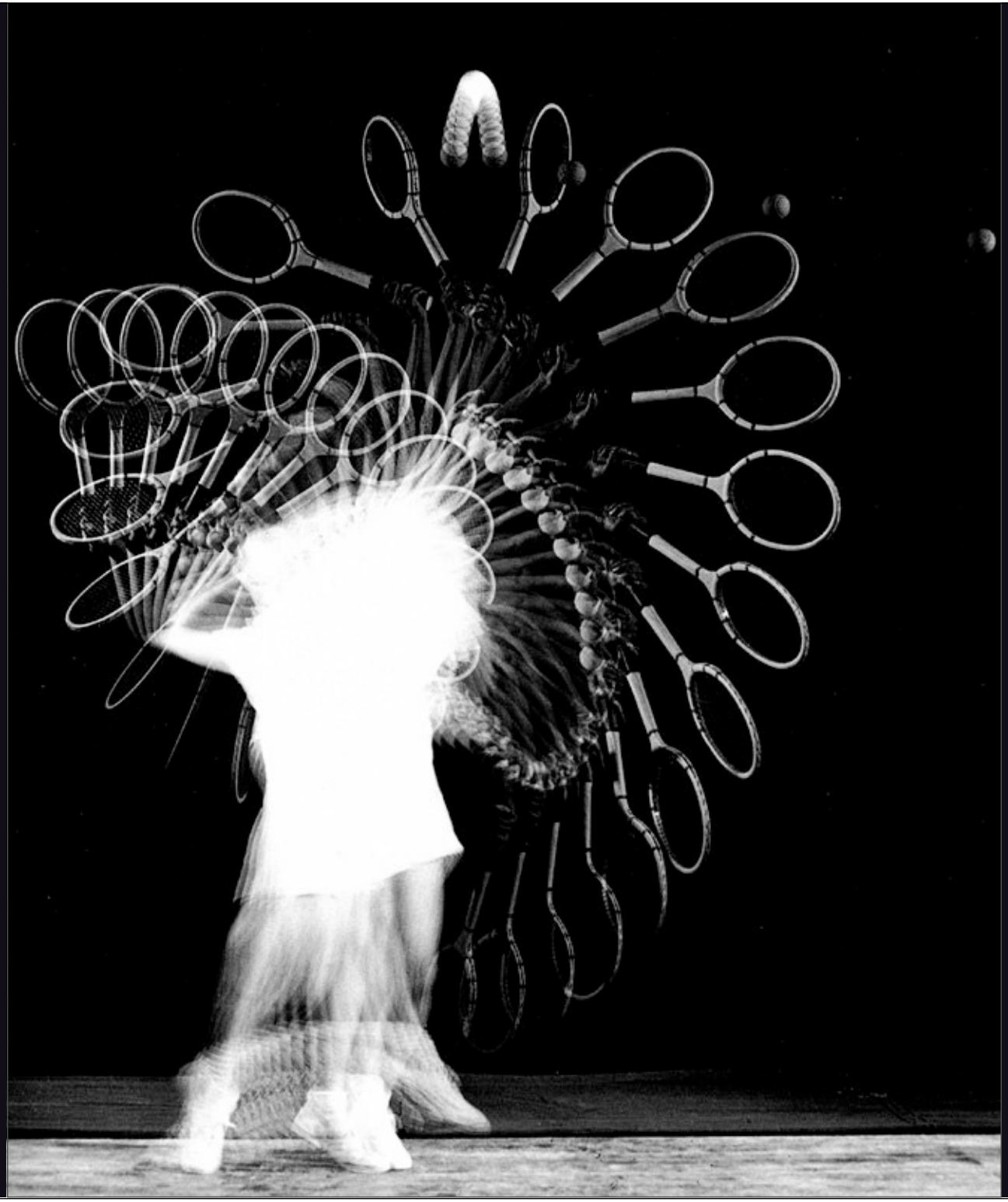
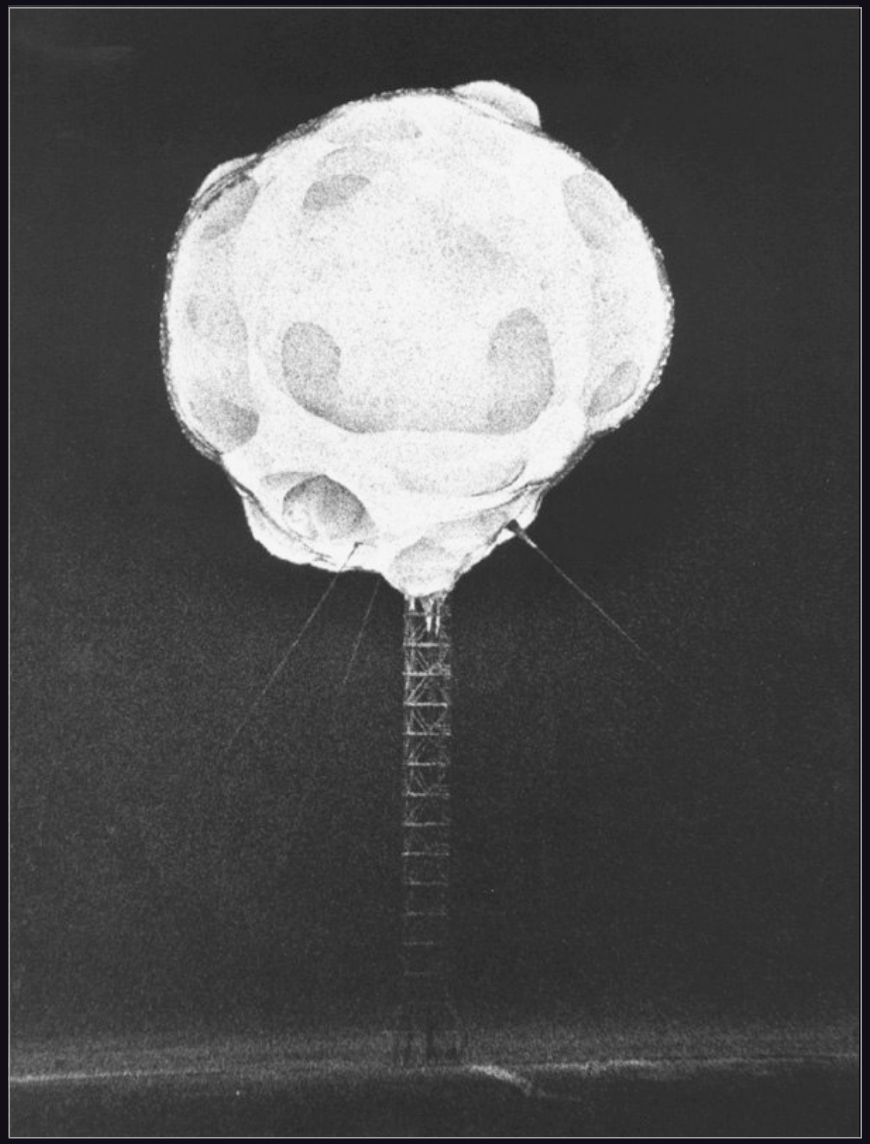


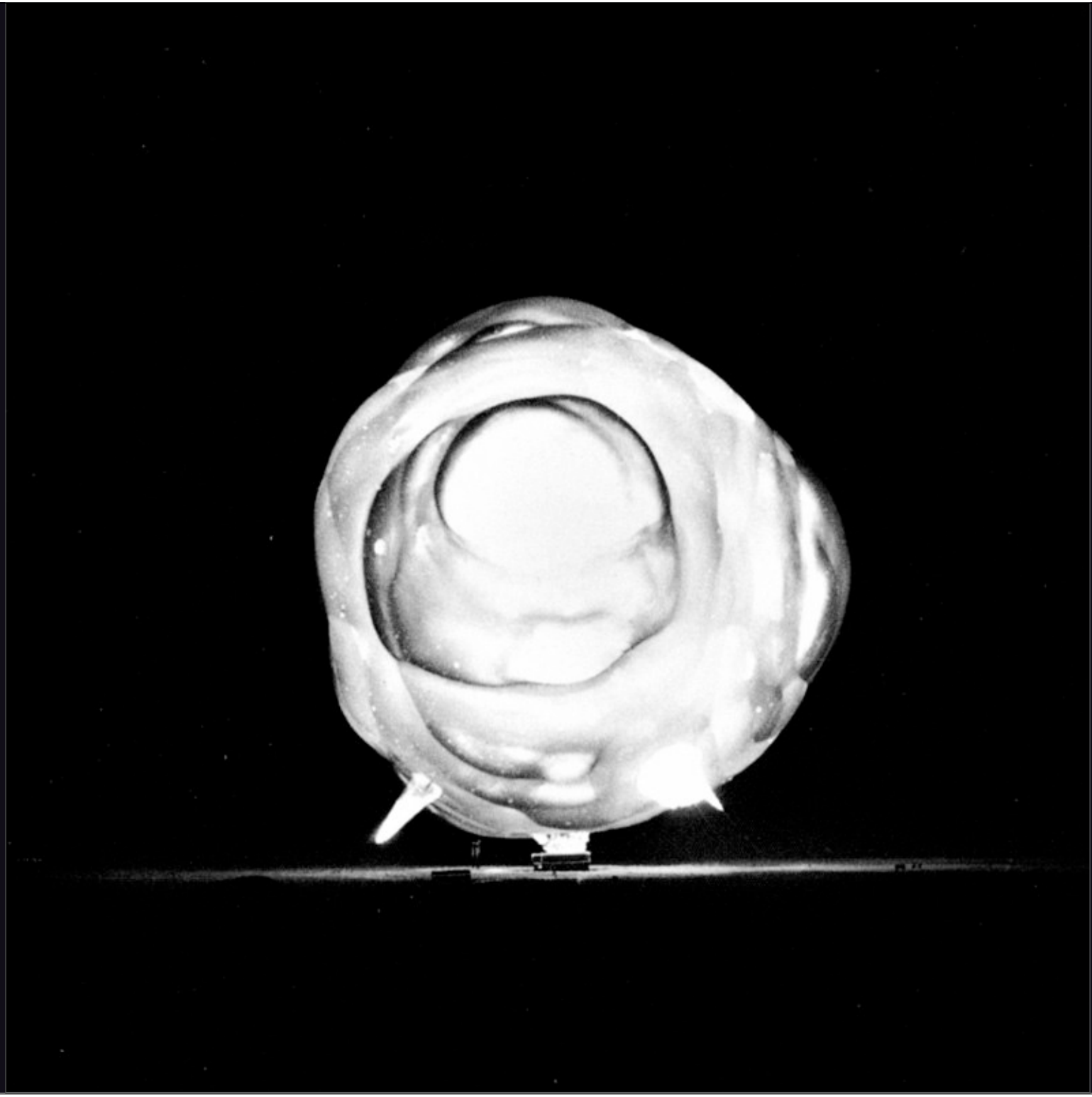


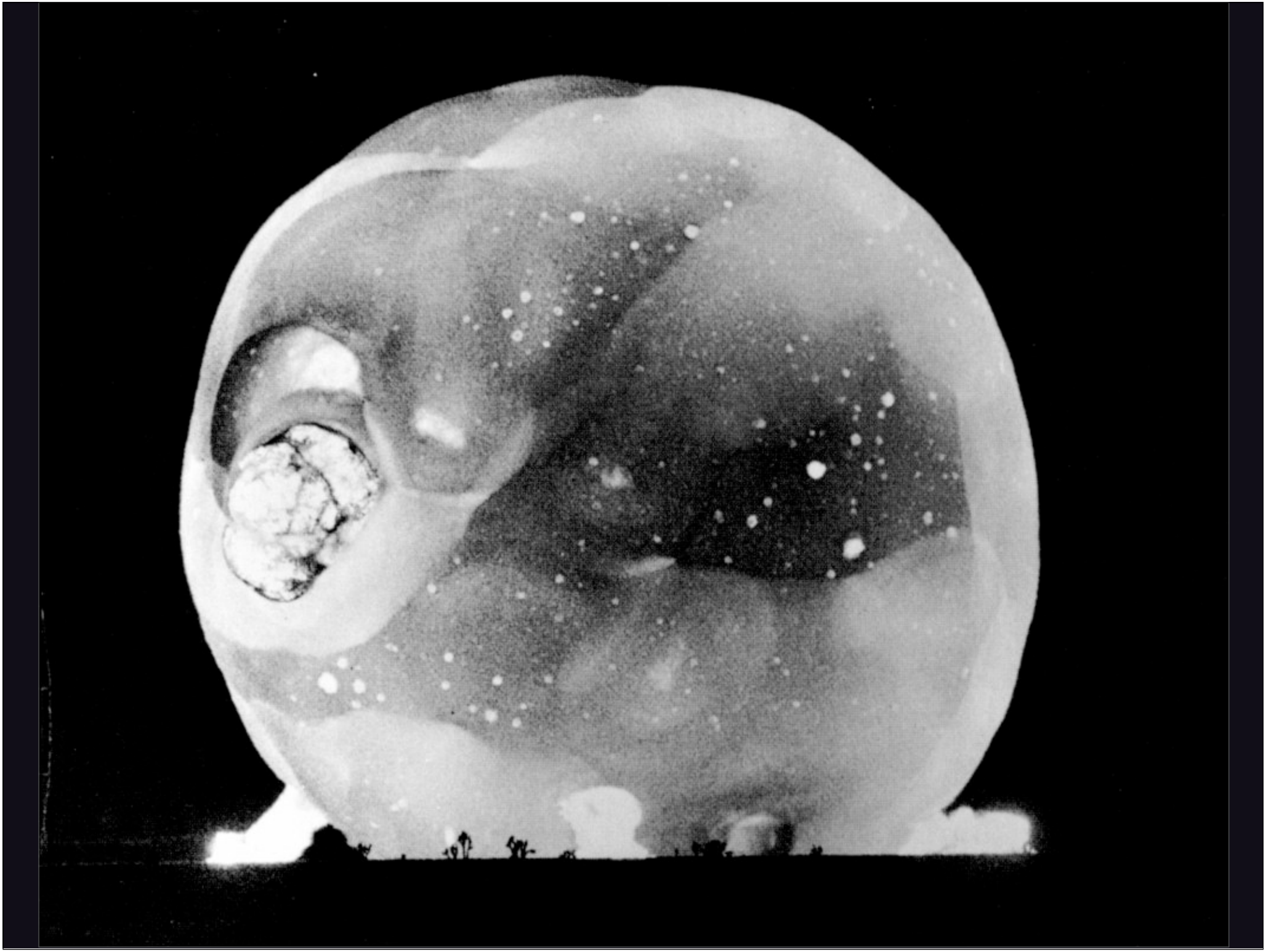


Ultra-high speed photography



- atomic explosion
- 1/100,000,000 second
- camera was *7* miles away
- telescopic lens





High-speed video with a still camera: the Casio EX-F1

- 640 × 480 pixels
- 300 frames per second
- border collie

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- 320 × 480 pixels
- 600 frames per second

- 160 × 480 pixels
- 1200 frames per second

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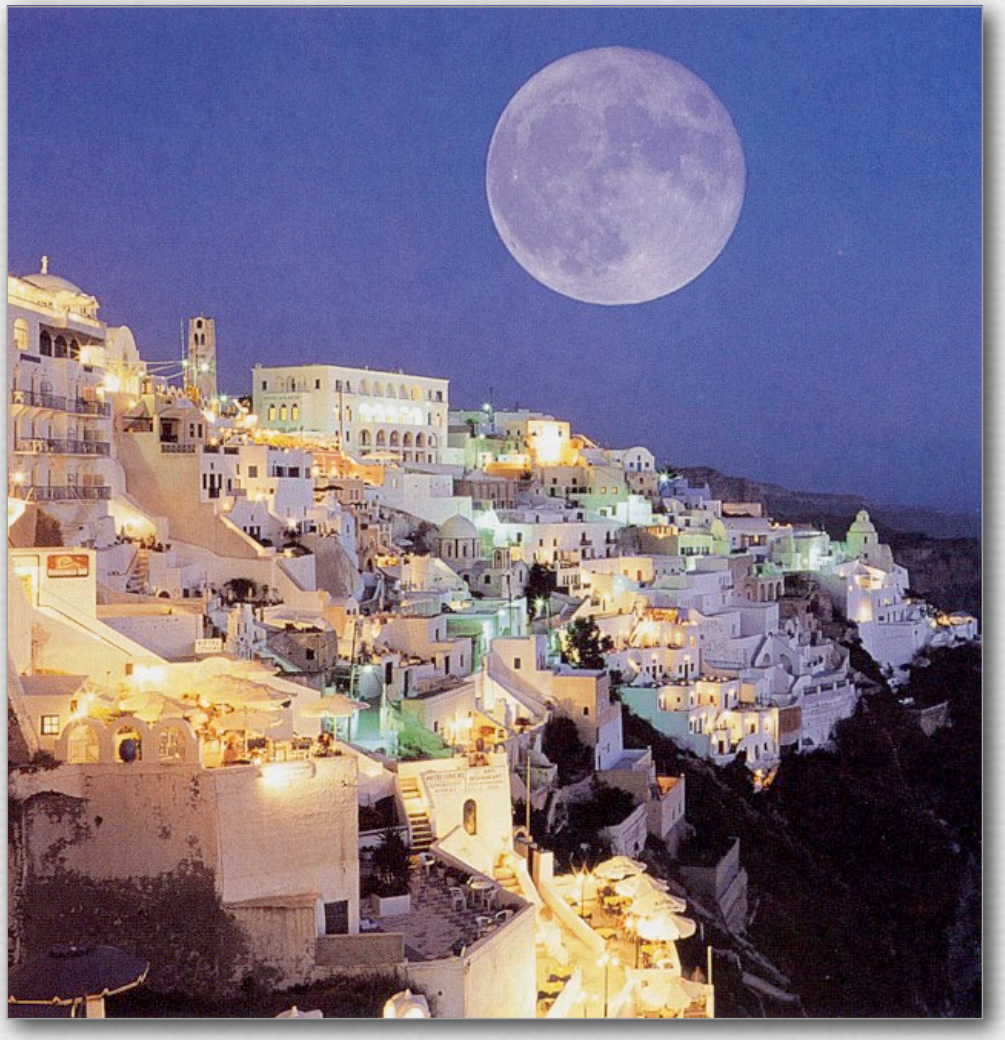
Low-light photography



Lee Frost, Santorini, Greece

- composite of two exposures
- cityscape was 30 seconds

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Time exposures in astonomy

Lee Frost, star trails

(Palomar 200-inch)

- 30-minute exposure
- telescopes can rotate to avoid smearing stars
- What is the unmoving star in the middle?

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Jesse Levinson, Andromeda

Painting with light

Lee Frost, railroad yard

- 30-second exposure
- multiple flashes
- Don't stand between the flashed part of the scene and the camera!

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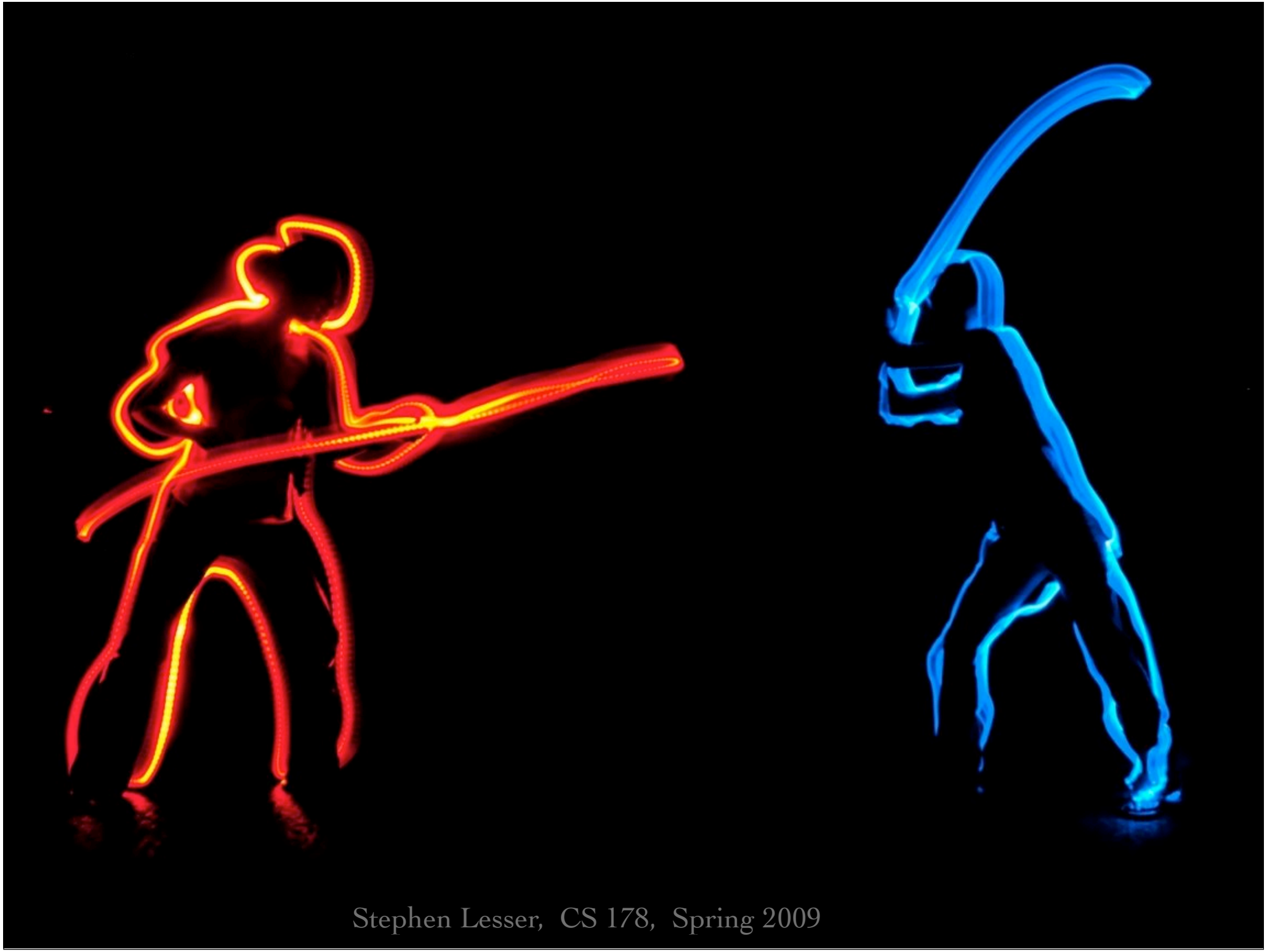

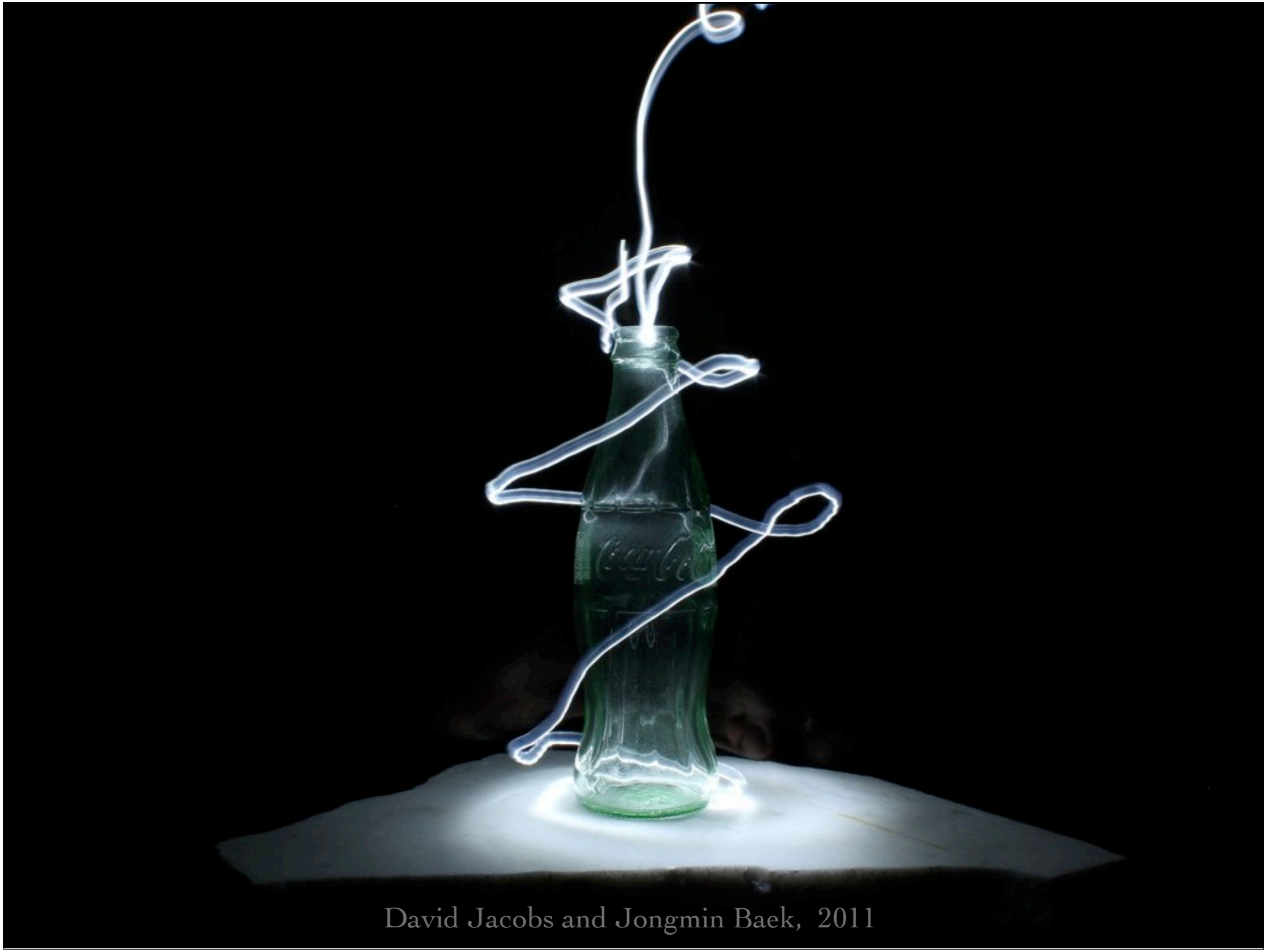

David Jacobs and Jongmin Baek, 2011

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Small aperture (large depth of field)

Ansel Adams, Mission San Xavier del Bac, Tucson

- the f/64 club

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Large aperture (shallow depth of field)

Lewis Hine, Girl Worker in Cotton Mill, 1908

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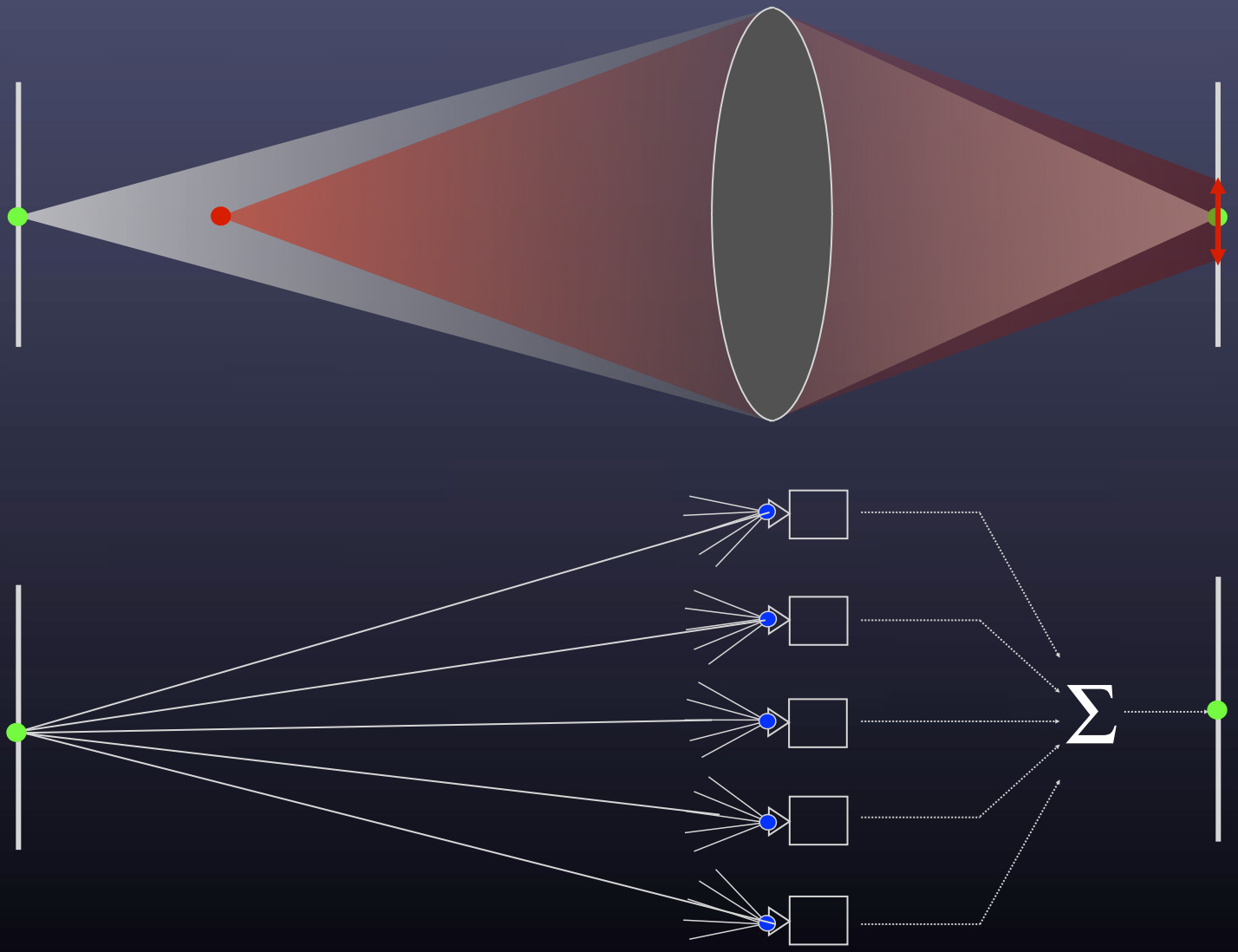
Synthetic aperture photography



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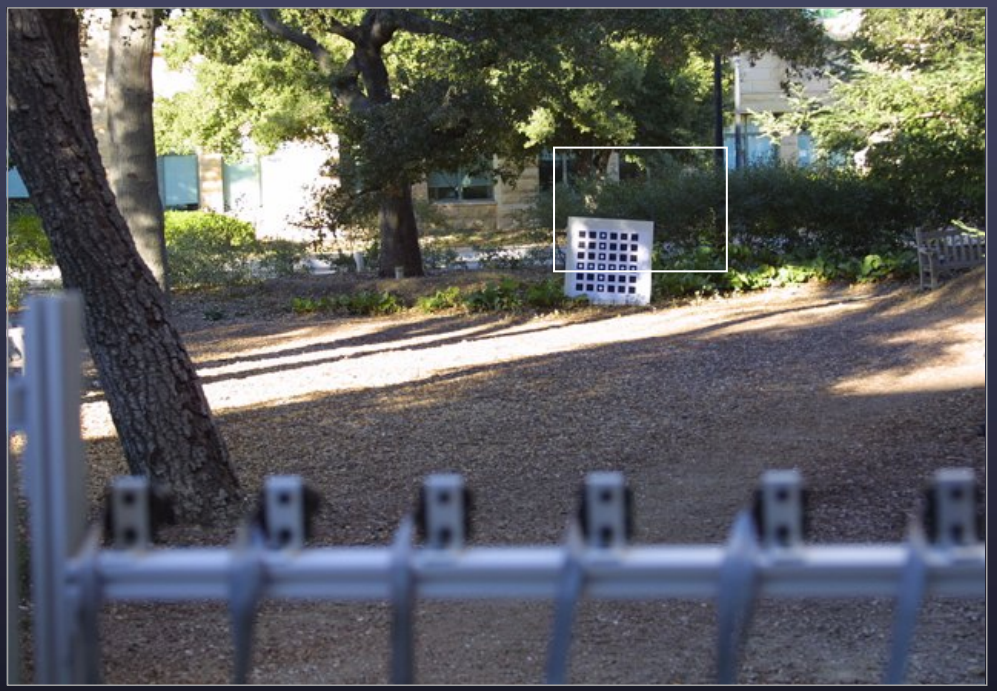
Example using 45 cameras
[Vaish CVPR 2004]



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SynthCam is an app for the iPhone 4, 3GS, iPod Touch 4G, and iPad2

(requires iOS 4.2 or higher)

Price: $0.99

Current version: 2.0

Available on the iPhone
App Store

single frame

synthetic aperture photograph

Tilt-shift of Stanford quadrangle as seen from Hoover Tower

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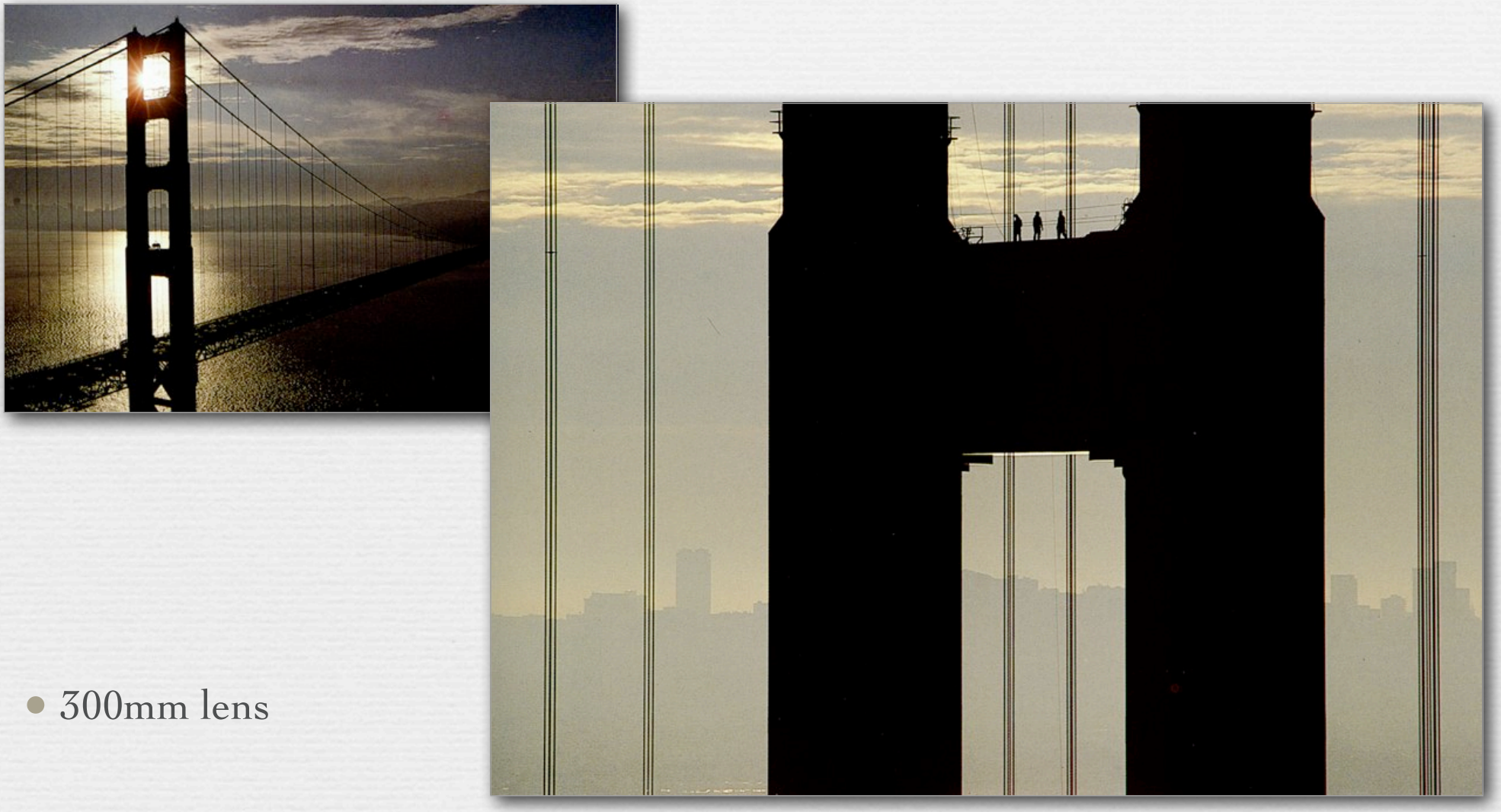
Narrow field of view: telephoto lens



- 300mm lens

Bryan Peterson, Golden Gate Bridge

© Marc Levoy

Extreme telephoto

- Nikon 1540mm Cassegrain reflector

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Other extreme telephoto lenses

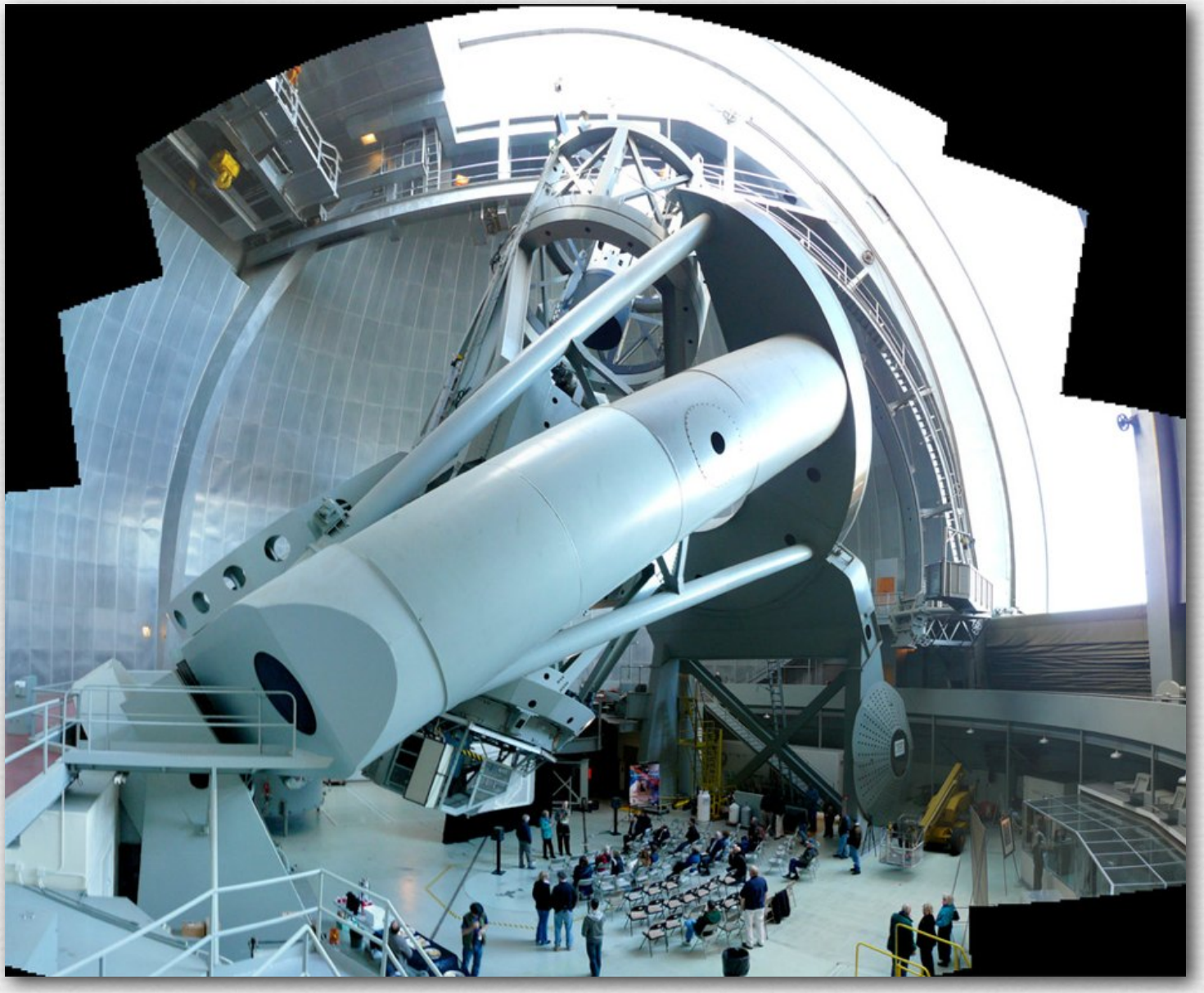
Canon 1200mm

Nikon 2000mm

Zeiss 1700mm

© Marc Levoy

Really extreme



Hale telescope on
Mt. Palomar, CA

A = 200” (16’)
f = 650” (50’)
N = f/3.3

© Marc Levoy

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Wide field of view: stitched panoramas

© Marc Levoy

Wide field of view: stitched panoramas

Crater Lake, Oregon

- 4 photos, total = 90° field of view
- Canon point-and-shoot camera, handheld
- stitched using Photoshop CS3

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Games with stitched panoramas

- 5 shots, with camera aimed slightly downwards and rolled clockwise around its optical axis between shots left to right, producing a curved world effect when stitched using Photoshop with cylindrical projection

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Nikon 6mm fisheye lens

- 220° field of view measured diagonally
- 11.4 pounds

(DigitalFreak.net)

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Stanford CityBlock Project (now Google StreetView)

- capture video while driving
- extract middle column from each frame
- stack them to create a panorama

© Marc Levoy

Stanford CityBlock Project

Stanford CityBlock Project

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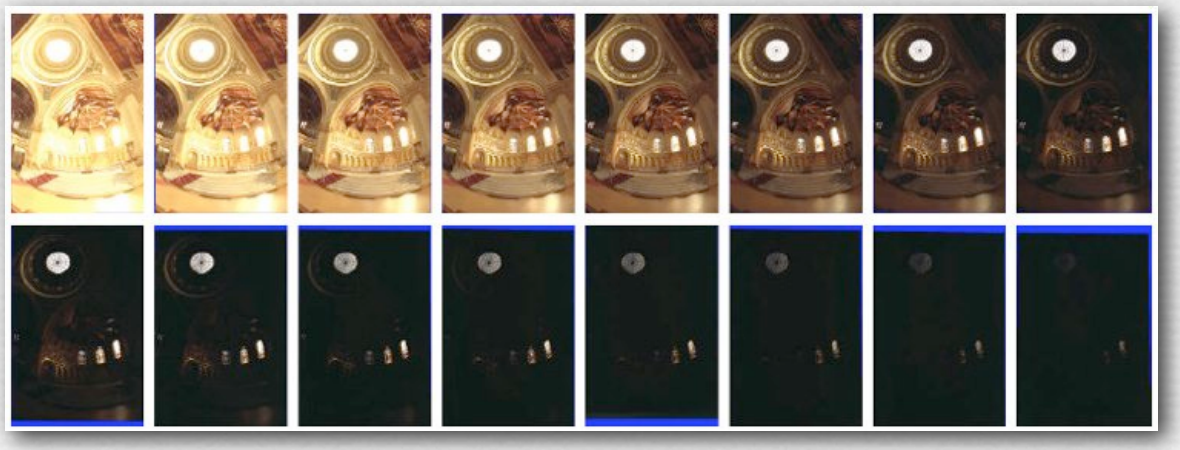
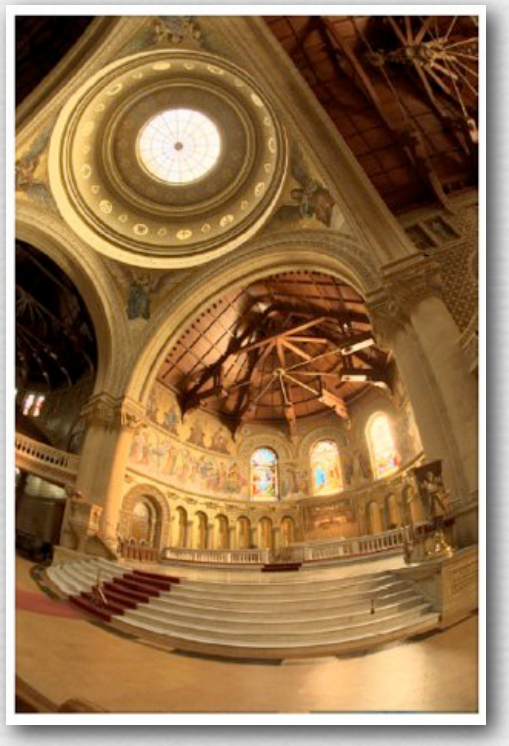
High dynamic range (HDR)

- one of photography's key limitations
  - negative film = 250:1 (8 stops)
  - paper prints = 50:1
  - example below = 250,000:1 (18 stops)



(Paul Debevec)

→



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DIY HDR

Early morning in Zurich

- 2 shots
- Photoshop CS4

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Atmospheric perspective according to Leonardo

Virgin and child with St. Anne

" the nearest objects will be bounded by evident and sharp boundaries, while those more distant will be... more blurred"

—*On Painting*

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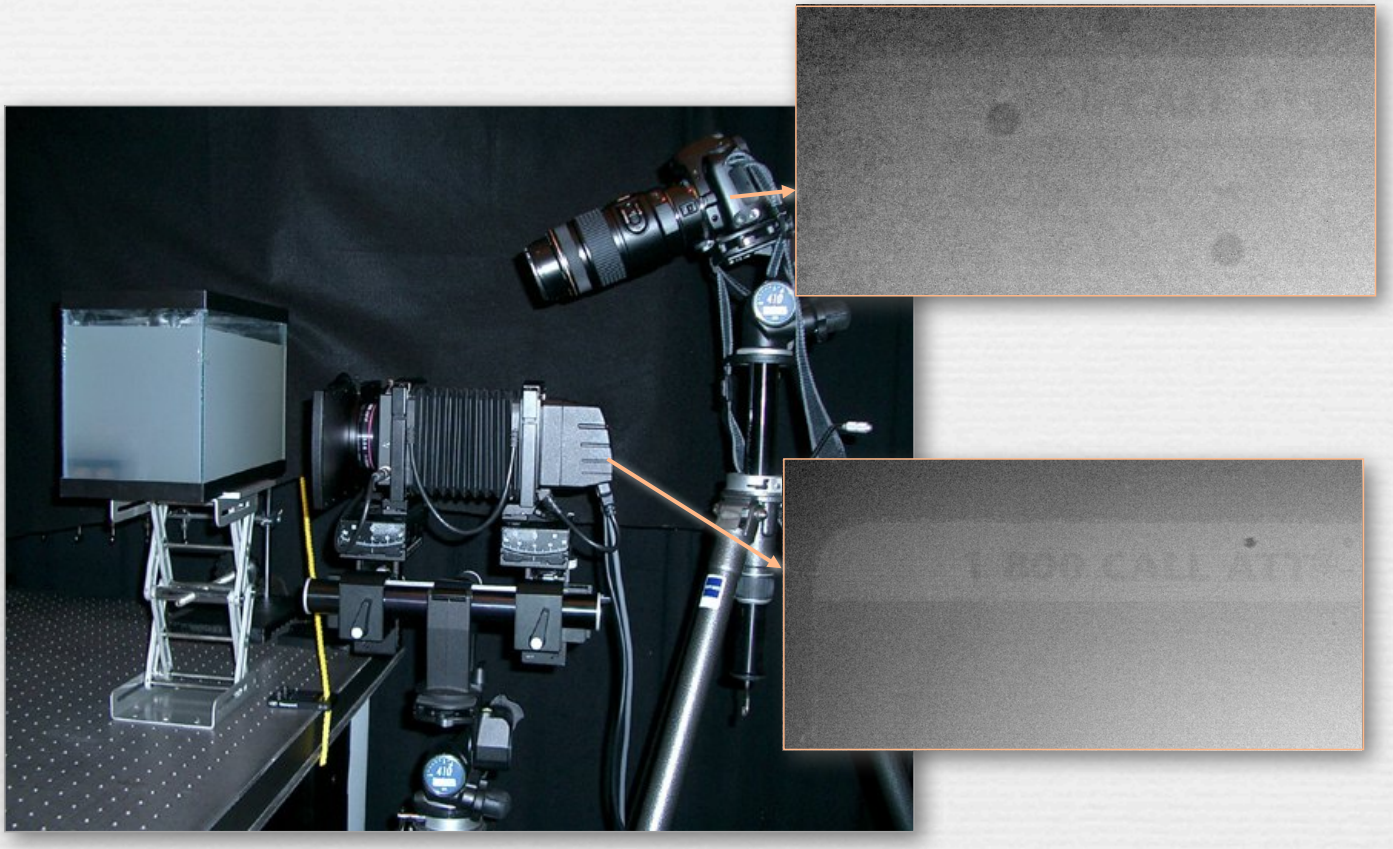
Sinar P3 view camera with 54H digital back



- 2¼ × 2¼ sensor, actively cooled, 14 real bits

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single frame
in dark room
using iPhone 4

average of
~30 frames
using SynthCam

SNR increases as
sqrt(# of frames)

Slide credits

(in addition to individually credited images)

- Kayafas, G., Jussim, E.., *Stopping Time: The Photographs of Harold Edgerton*, Harry Abrams Inc., 1987.
- Frost, L., *Night & Low-Light Photography*,Watson-Guptill, 1999.
- Peterson, B., *Learning to See Creatively*, Watson-Guptill, 1988.
- Kemp, M., *Leonardo On Painting*, Yale University, 1989.
- http://gigapixl.org
- http://xrez.com

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