Lecture 6

- Index notation
- Observational techniques
- Important contributions to opacity
- LASP visit 8:30-9:45

Summary of previous lecture

- More on neutrino observations
- Center to limb variation
- Maxwell equations
- Index notation
- LASP visit 8:30-9:45

Index notation (1st exposure)

divergence

$$\nabla \cdot \mathbf{F} = \sum_{i=1}^{3} \frac{\partial}{\partial x_i} F_i \equiv \frac{\partial}{\partial x_i} F_i \equiv \partial_i F_i$$

Einstein's summation convention

Subscript means spatial coordinate direction

curl

$$\left(\nabla \times \mathbf{F}\right)_i = \varepsilon_{ijk} \partial_j F_k$$

$$\left(\mathbf{G} \times \mathbf{F}\right)_i = \varepsilon_{ijk} G_j F_k$$

$$\varepsilon_{123} = \varepsilon_{231} = \varepsilon_{312} = 1$$

$$\varepsilon_{321} = \varepsilon_{213} = \varepsilon_{132} = -1$$

$$\varepsilon_{ijk} = 0 \text{ otherwise}$$

Application (useful for homework!)

Divergence and cross product combined: use product rule

$$\nabla\cdot\left(\mathbf{E}\times\mathbf{B}\right)=\varepsilon_{ijk}\partial_i\left(E_jB_k\right)$$
$$=\varepsilon_{ijk}\left(\partial_iE_j\right)B_k+\varepsilon_{ijk}E_j\left(\partial_iB_k\right)$$

Re-express in terms of vector notation

$$\nabla\cdot\left(\mathbf{E}\times\mathbf{B}\right)=\left(\varepsilon_{kij}\partial_iE_j\right)B_k+E_j\left(\varepsilon_{jki}\partial_iB_k\right)$$
$$=\left(\varepsilon_{kij}\partial_iE_j\right)B_k-E_j\left(\varepsilon_{jik}\partial_iB_k\right)$$
$$=\left(\nabla\times\mathbf{E}\right)\cdot\mathbf{B}-\mathbf{E}\cdot\left(\nabla\times\mathbf{B}\right)$$

Kronecker tensor

$\delta_{11} = \delta_{22} = \delta_{33} = 1$
and 0 otherwise

what is δ_{ii} ??

A. 0
B. 1
C. 2
D. 3
E. 4

Levi-Civita tensor

$$\varepsilon_{123} = \varepsilon_{231} = \varepsilon_{312} = 1$$

$$\varepsilon_{321} = \varepsilon_{213} = \varepsilon_{132} = -1$$

$$\varepsilon_{ijk} = 0 \text{ otherwise}$$

Also: totally antisymmetric tensor

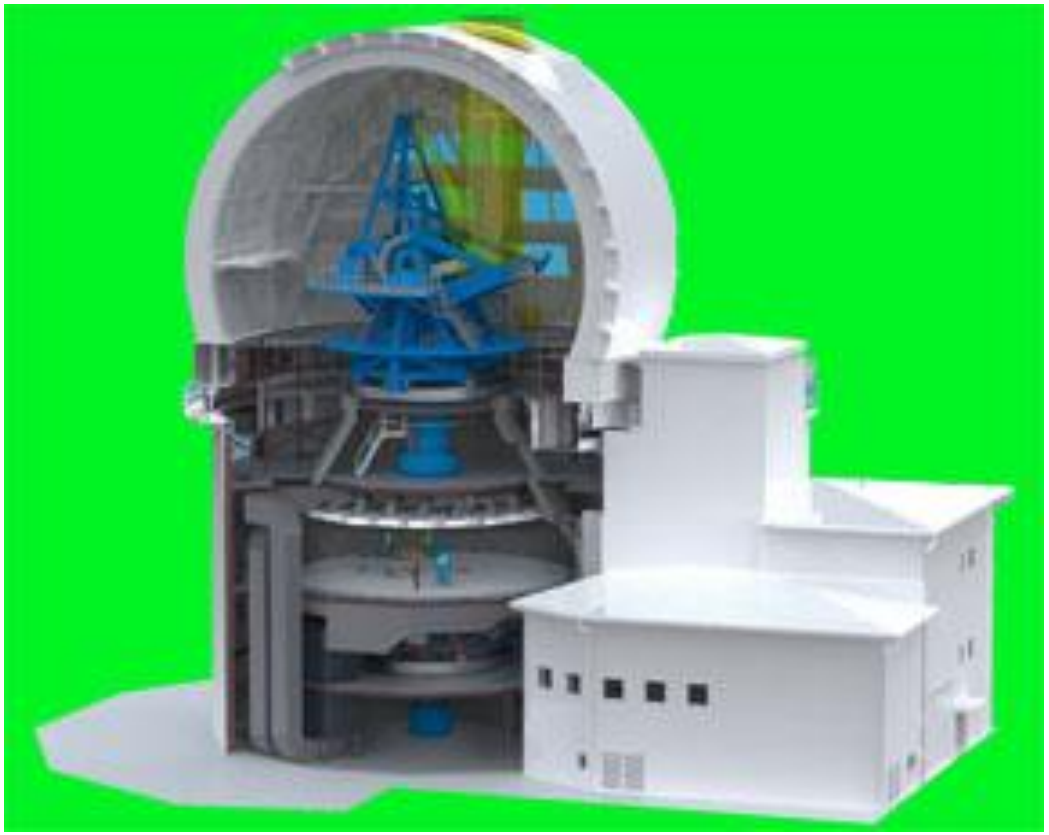
what is $\varepsilon_{ijk}\varepsilon_{ijk}$??

A. 0
B. 1
C. 3
D. 4
E. 6

Observational techniques

Name/Observatory	Image	Aperture d.	Year(s)	Location	Country(s)	
COronal Solar Magnetism Observatory (COSMO)[1]	-	150 cm	proposed	Hawaii, USA	United States	
Chinese Large Solar Telescope	-	180 cm	constructing	Western part of China	China	
National Large Solar Telescope	-	200 cm	proposed[2]	Merak Village, Ladakh, India	India	
Chinese Giant Solar Telescope	-	500–800 cm	planned	Western part of China	China	Could be the world's largest s
European Solar Telescope (EST)[4]	-	400+ cm	planned	Canary Islands	15 European countries[5]	
Daniel K. Inouye Solar Telescope (formerly Advanced Technology Solar Telescope (ATST))	-	424 cm[6]	under construction [7]	Maui, Hawaii, USA	United States	
GREGOR solar telescope, Teide Obs.		150 cm	2012–	Tenerife, Spain	Germany	[8]
BBO NST, BBS Obs.		160 cm	2008–	California, USA	United States	Largest aperture solar telesc
New Vacuum Solar Telescope (NVST)	-	100 cm	2010–	Yunnan Astronomical Observatory, China	China	100 cm vacuum solar telesco
ONSET (Optical and Near-Infrared Solar Eruption Tracer)	-	3x27,5 cm	2010–	Yunnan Astronomical Observatory, China	China	The ONSET consists of four tu aperture of 27.5 cm, (2) a ch 27.5 cm, (3) a WL vacuum tub tube.[10]
Bulgarian 15-cm Solar Coronagraph,[11] NAO - Rozhen	-	100 cm	2005–	Rozhen, Bulgaria	Template:BG	
Swedish 1-m Solar Telescope[12](SST), ORM		100 cm	2002–	La Palma, Spain	Sweden	

Solar Telescopes

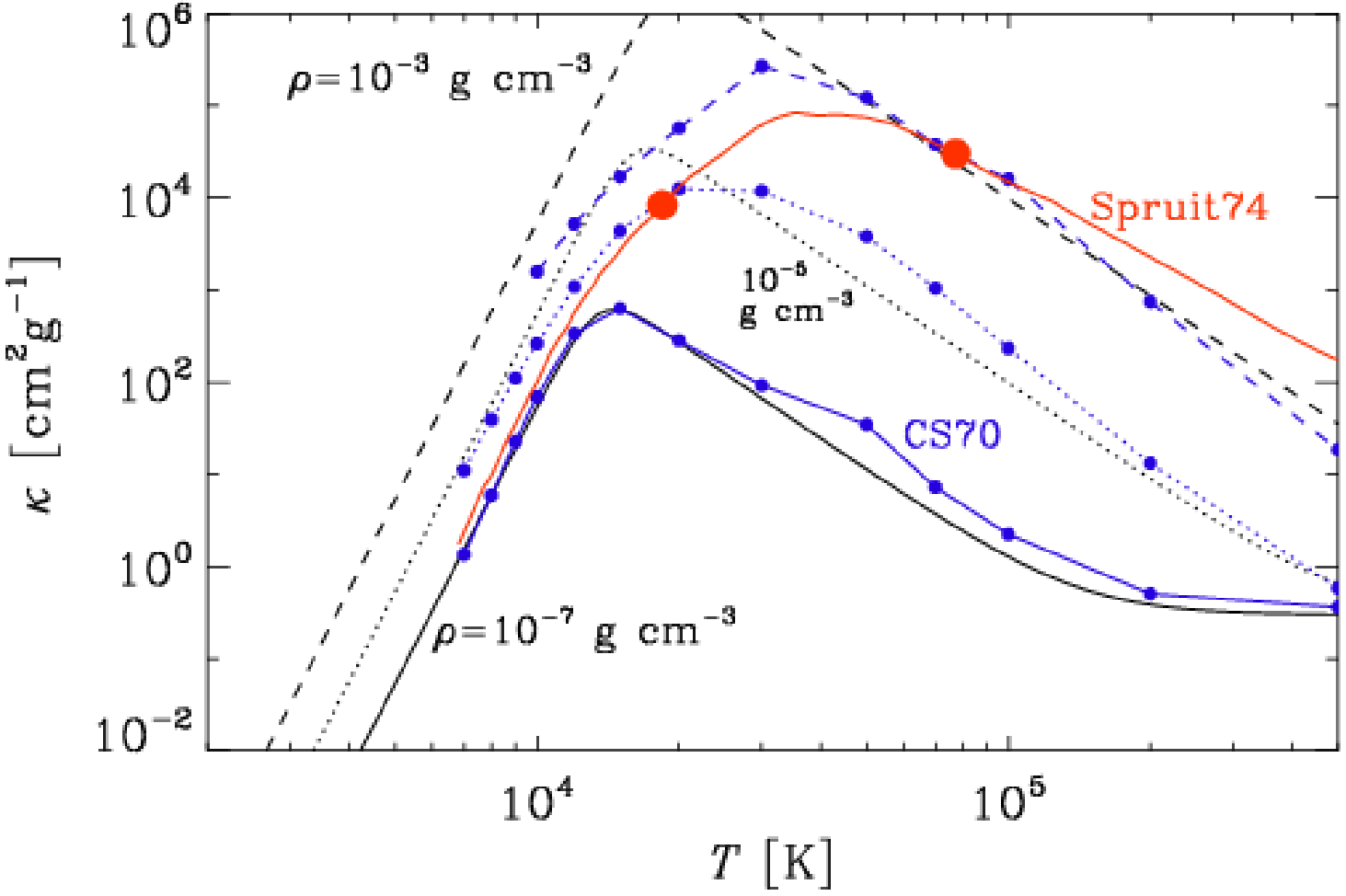


- Daniel K. Inouye Solar Telecope (DKIST)
- Heating, seeing, active optics, polarization

Opacity

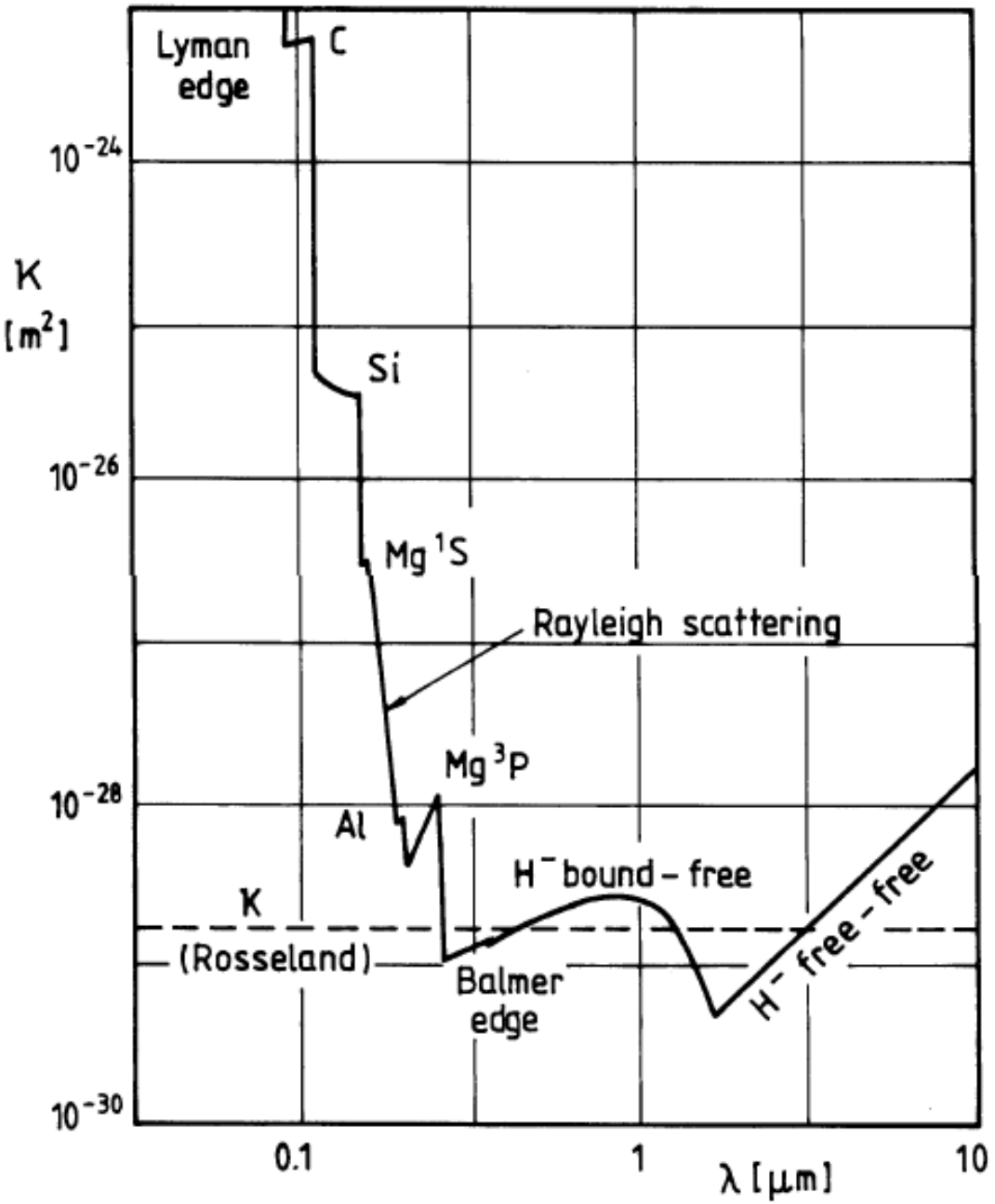
- Electron scattering
  - EM passes by e^-, makes it oscillate
  - It radiates in other directions
- Free-free transitions, and similar
  - e^- passes by an ion
  - absorbs & emits during time $\sim 1/v \sim T^{-1/2}$
- Negative Hydrogen ion
  - Neutral ion is polarized by nearby charge
  - Then attracts & binds another e^-

T and ρ dependence, solar model

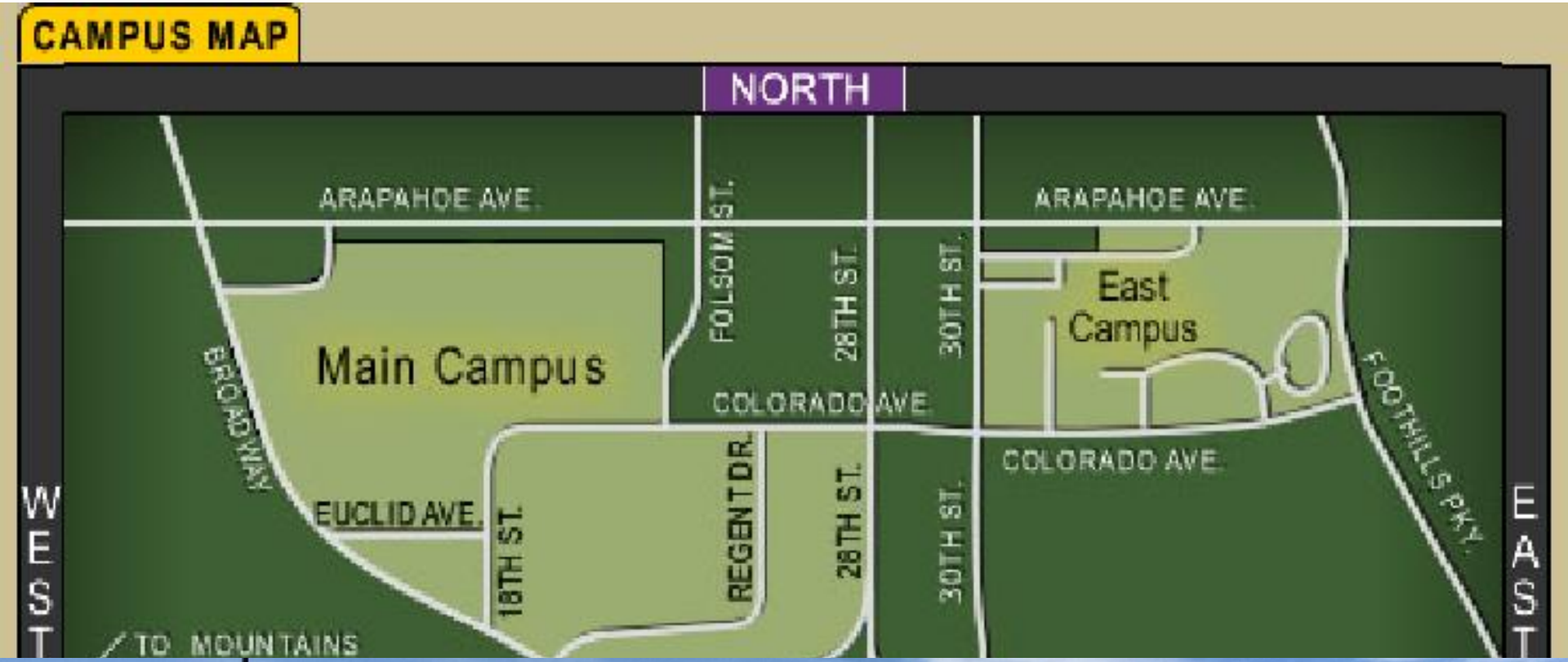


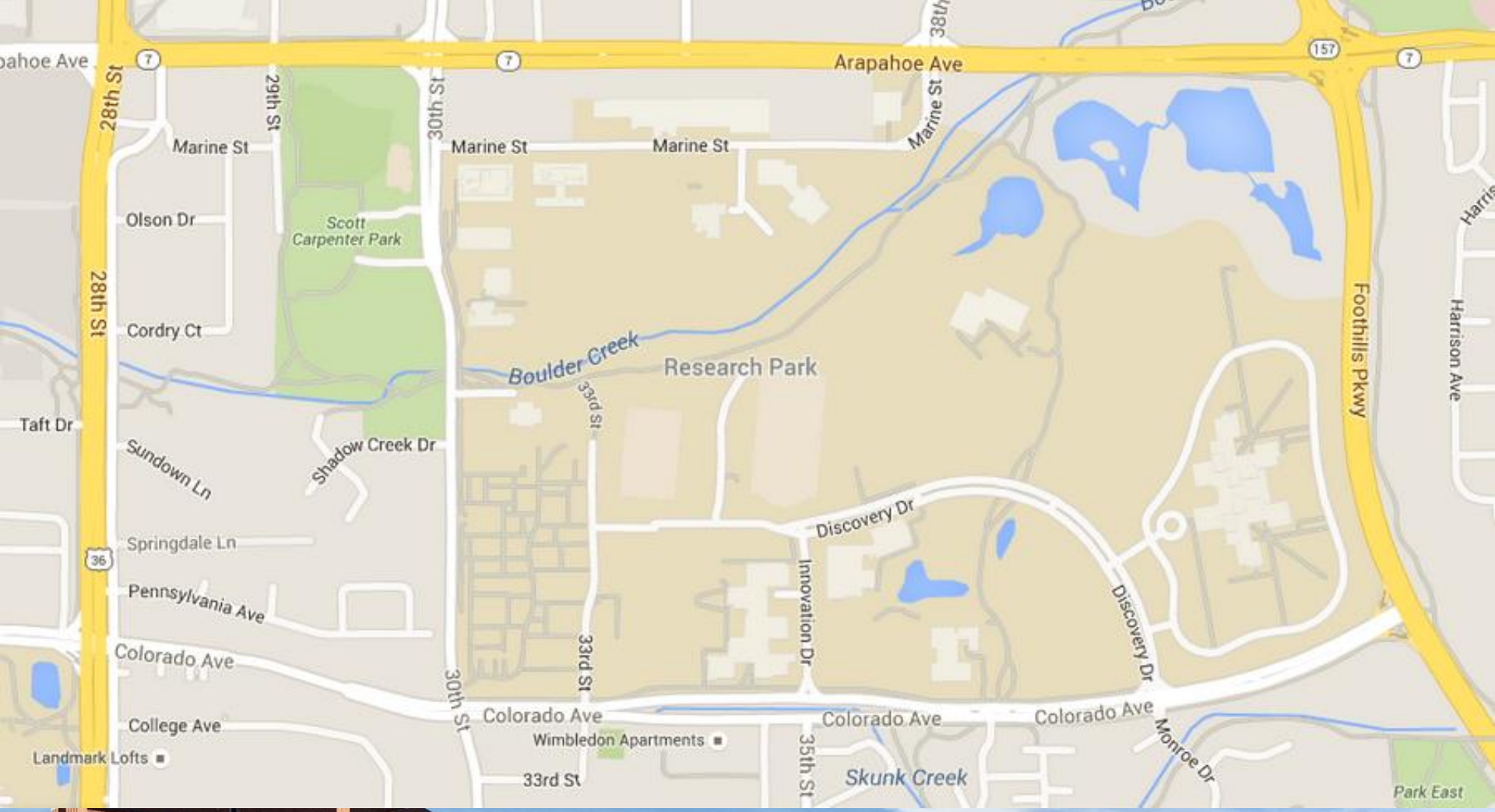
Opacity

- Increases toward red
- Strong absorption in UV
- Quadratic increase in IR



LASP visit on Wednesday 8:30-9:45

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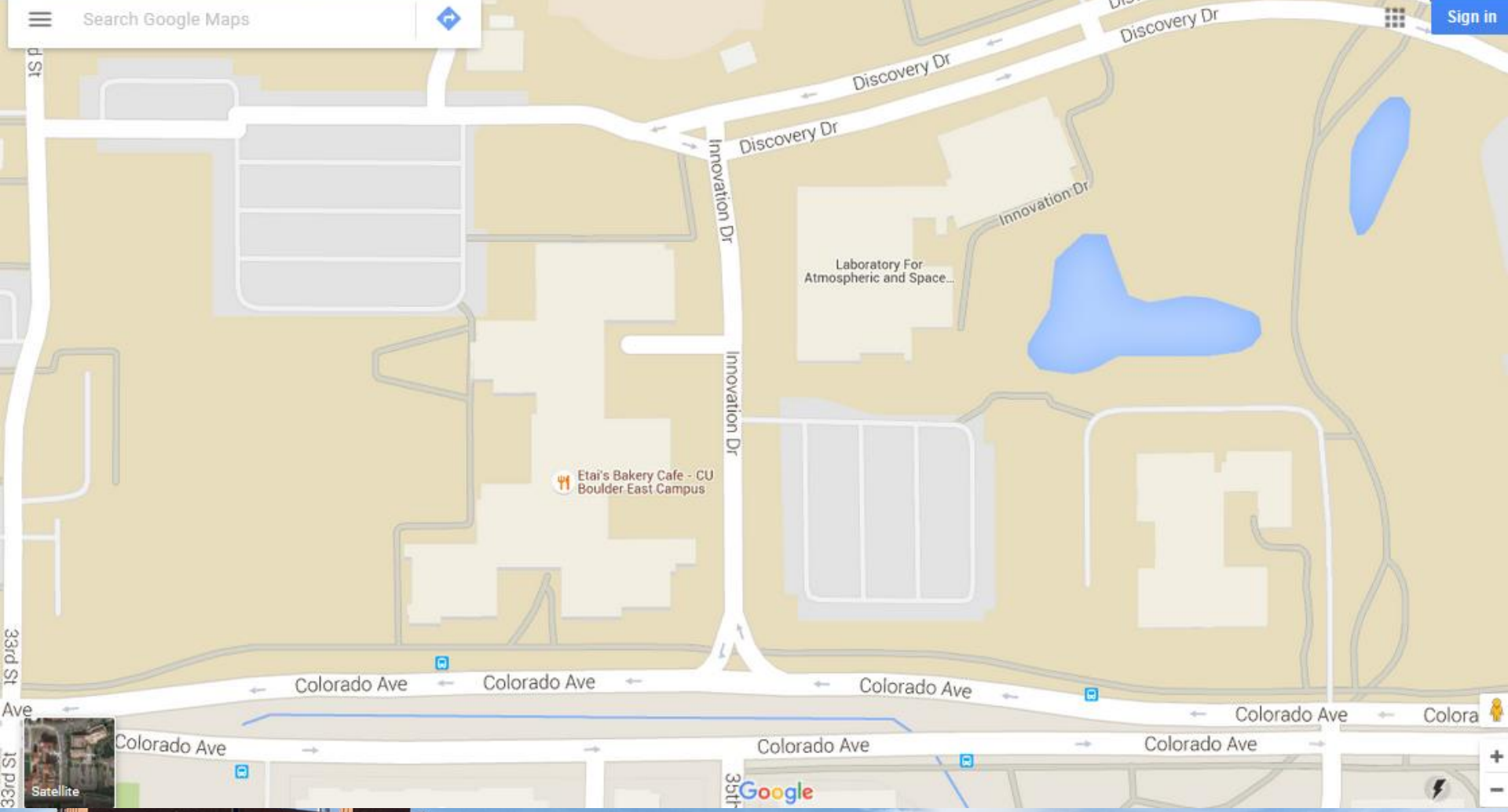
30th St
38th St
Marine St
Marine St
Marine St
Olson Dr
Scott Carpenter Park
Cordry Ct
Boulder Creek
Research Park
33rd St
Taft Dr
Sundown Ln
Shadow Creek Dr
Springdale Ln
Pennsylvania Ave
Colorado Ave
College Ave
Landmark Lofts
30th St
Colorado Ave
Wimbledon Apartments
33rd St
Discovery Dr
Innovation Dr
Discovery Dr
Colorado Ave
Colorado Ave
Monroe Dr
35th St
Skunk Creek
Foothills Pkwy
Harrison Ave
Park East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