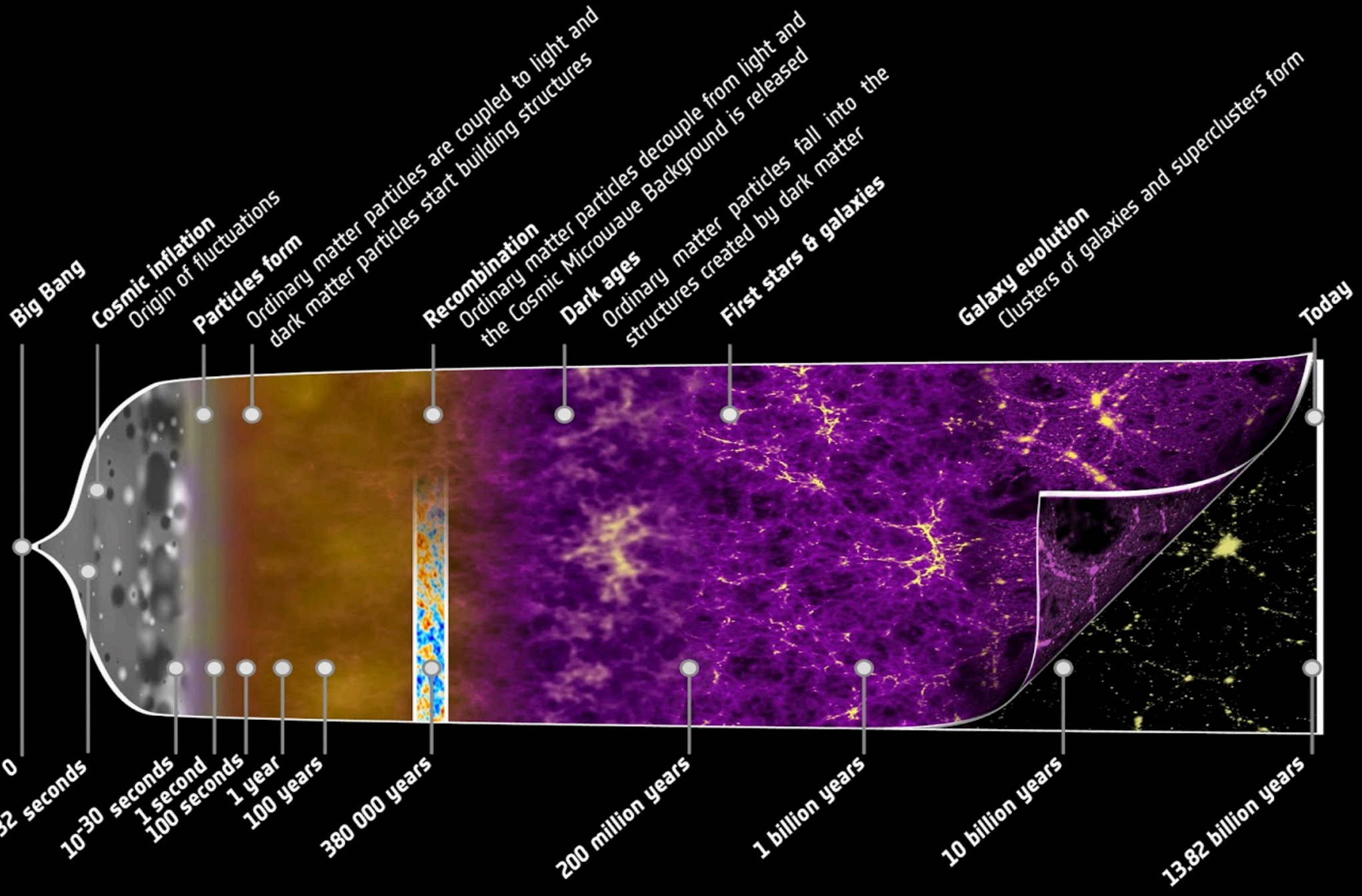
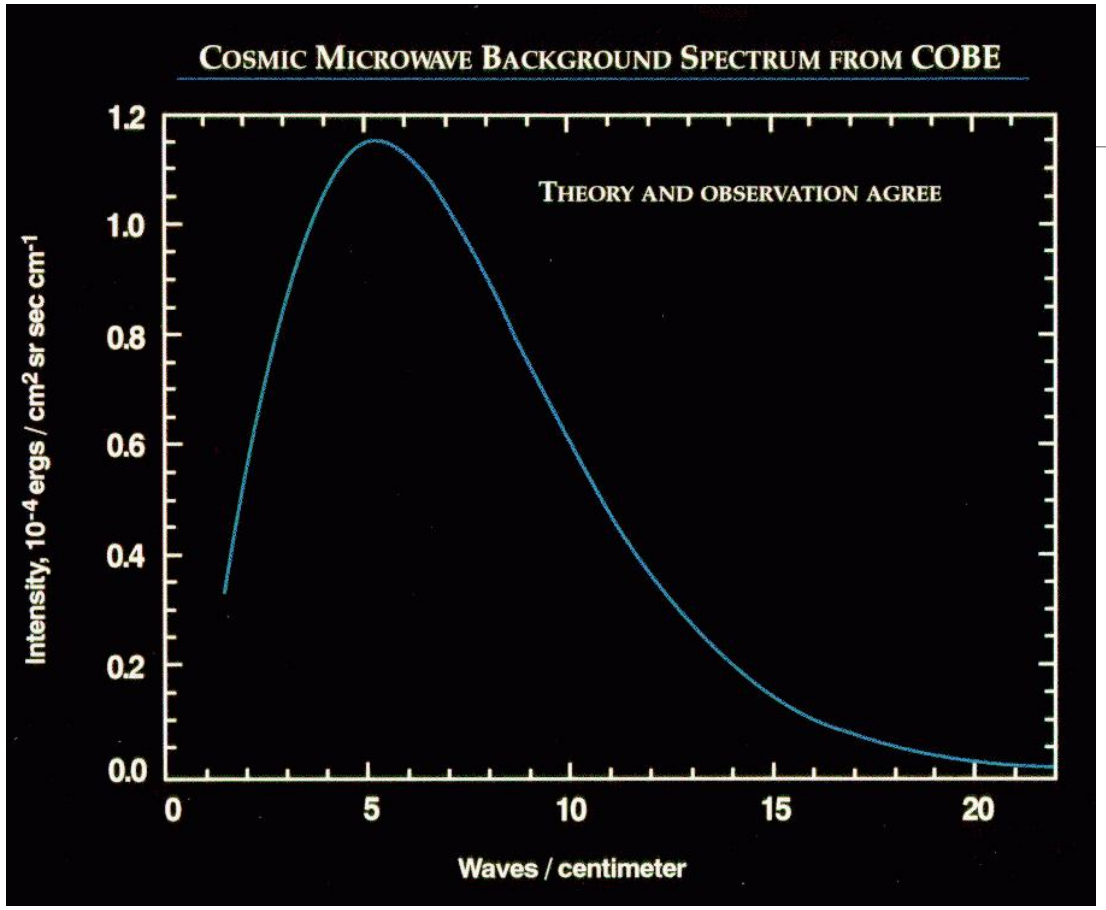
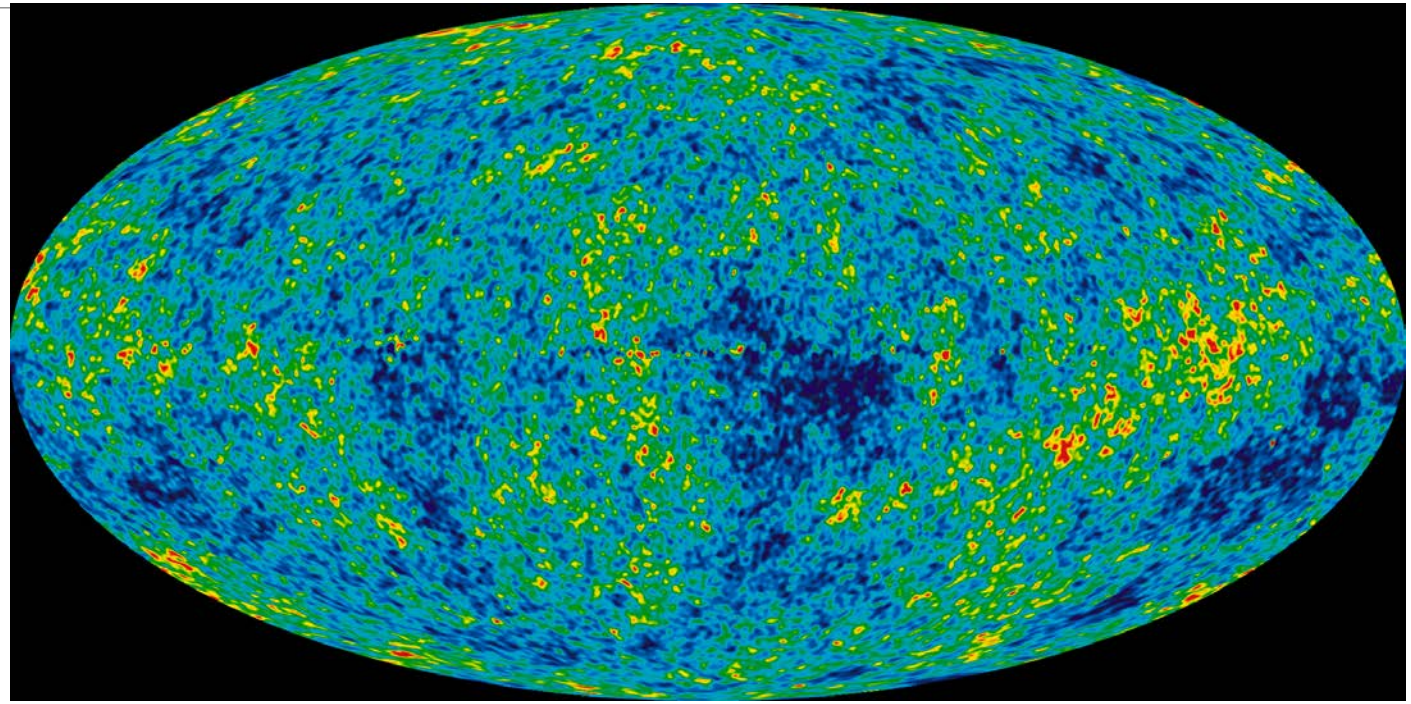
Infrared Response of a Quasi-Crystalline Filter

SAMANTHA G. PEDEK

UNIVERSITY OF WISCONSIN-RIVER FALLS

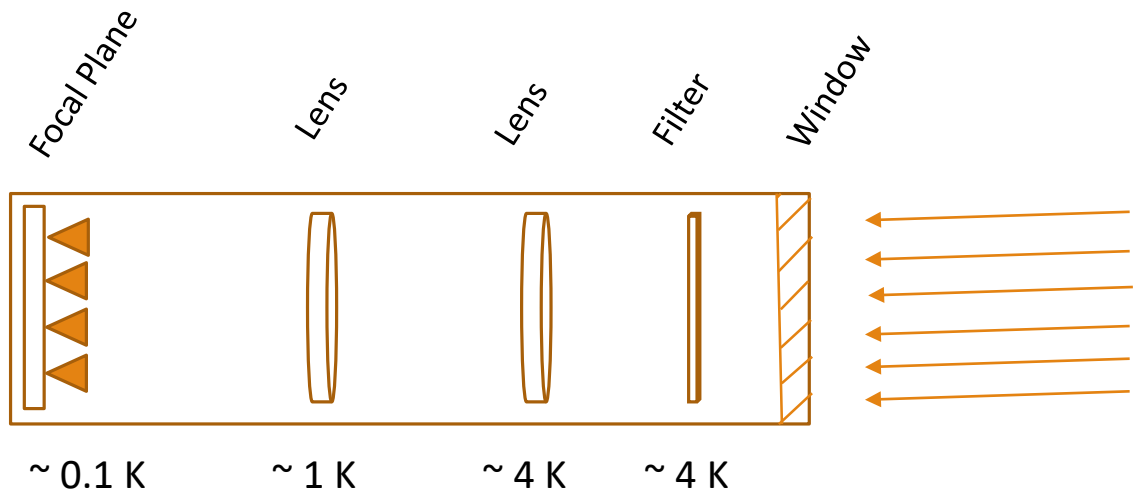

Big Bang
0
Cosmic inflation
Origin of fluctuations
10-32 seconds
Particles form
10-30 seconds
1 second
100 seconds
1 year
100 years
Ordinary matter particles are coupled to light and dark matter particles start building structures
Recombination
380 000 years
Ordinary matter particles decouple from light and the Cosmic Microwaue Background is released
Dark ages
200 million years
Ordinary matter particles fall into the structures created by dark matter
First stars & galaxies
1 billion years
Galaxy evolution
Clusters of galaxies and superclusters form
10 billion years
Today
13.82 billion years


COSMIC MICROWAVE BACKGROUND SPECTRUM FROM COBE
THEORY AND OBSERVATION AGREE
Intensity, 10⁻⁴ ergs / cm² sr sec cm⁻¹
1.2
1.0
0.8
0.6
0.4
0.2
0.0
0
5
10
15
20
Waves / centimeter

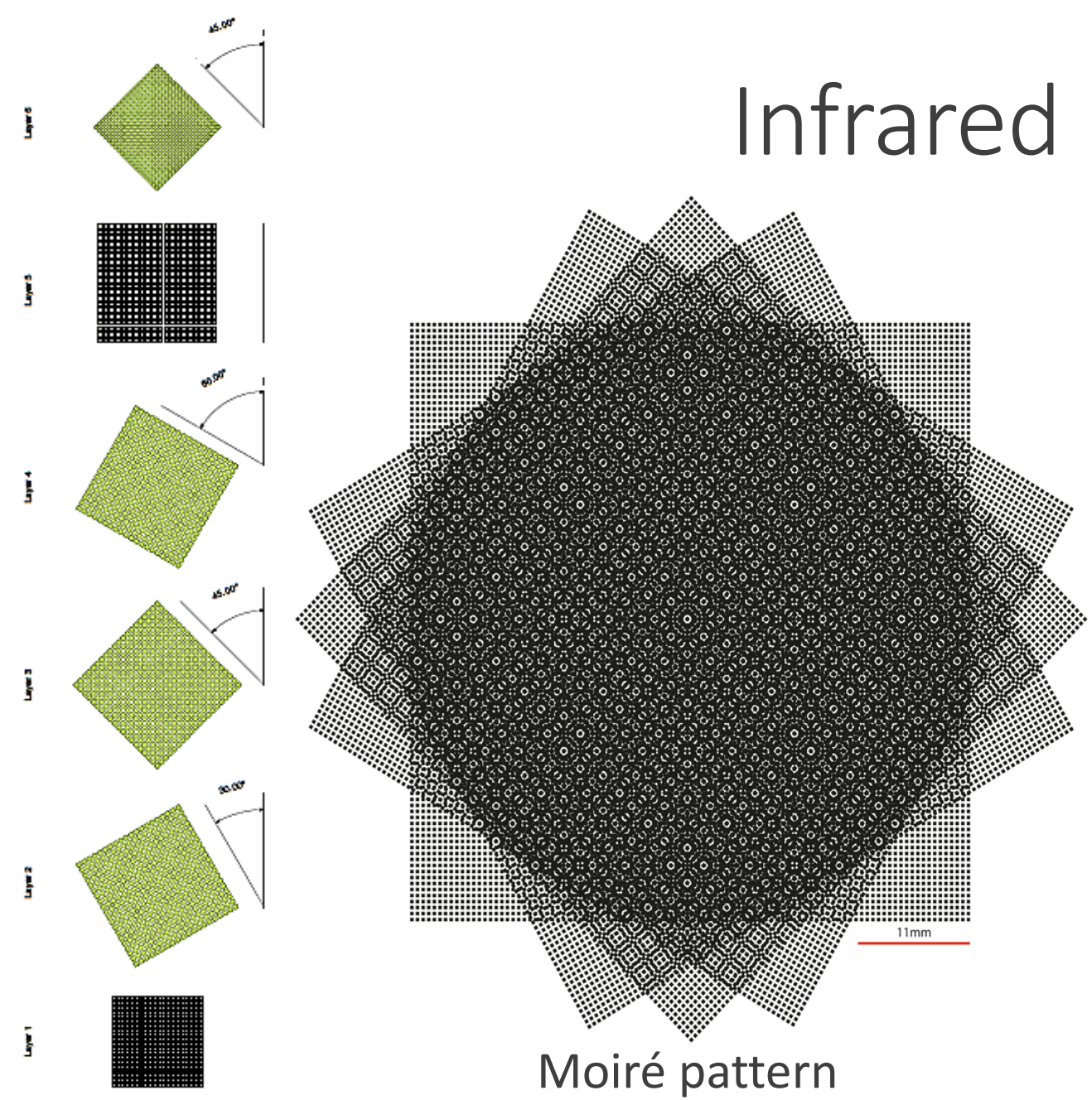


Infrared Radiation

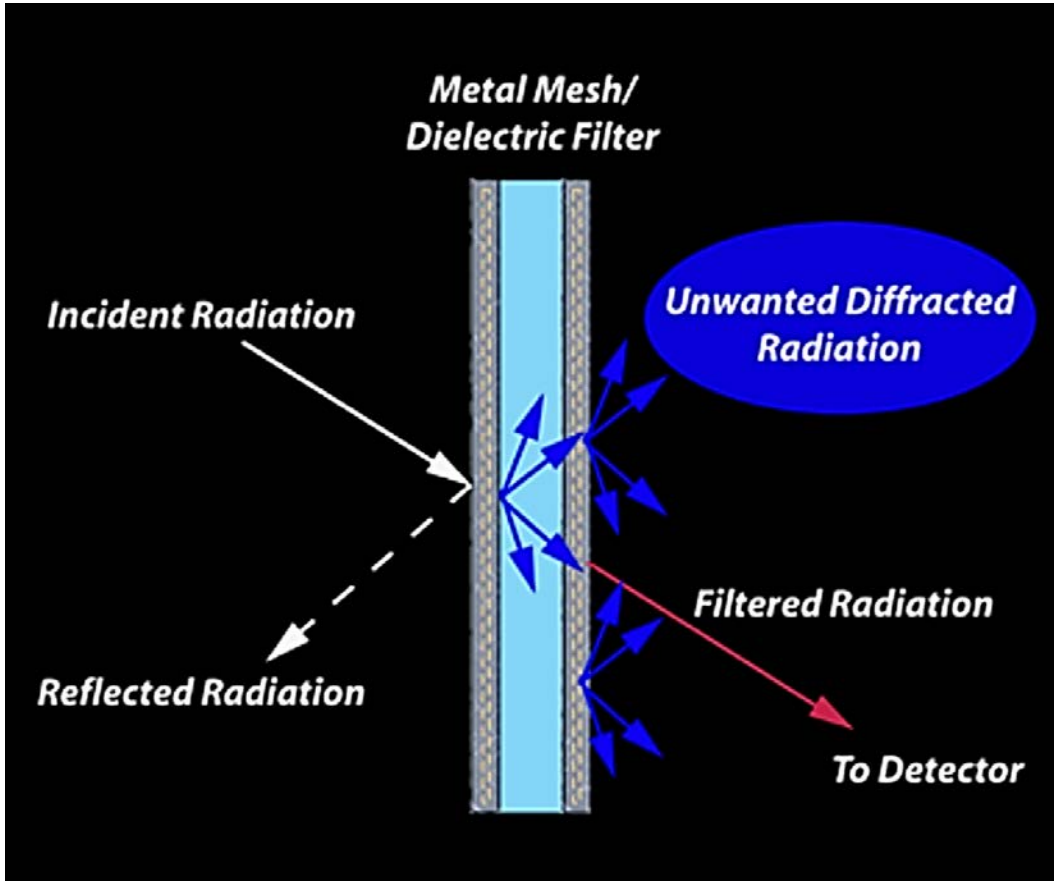
- CMB detectors are extremely sensitive
- Infrared photons warm the detectors and degrade performance
- Need infrared filters to reject IR radiation



Infrared Filters

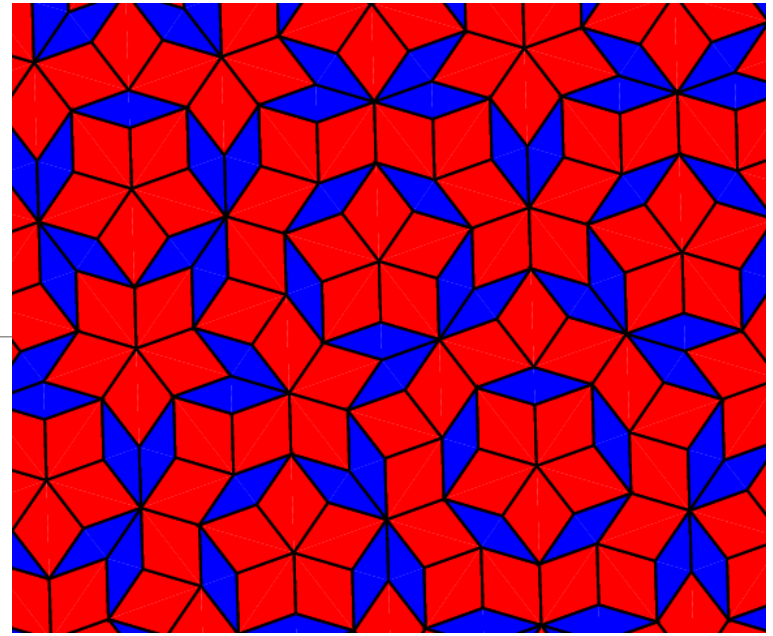


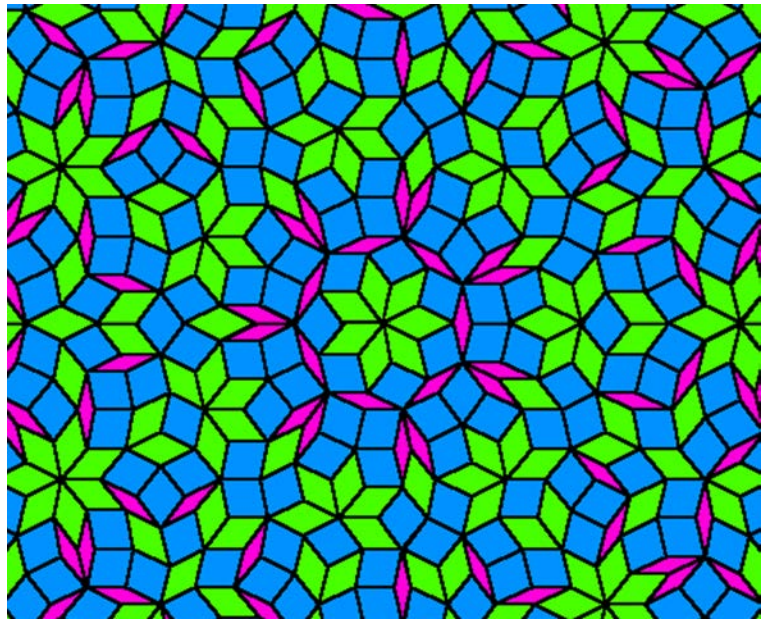
Moiré pattern

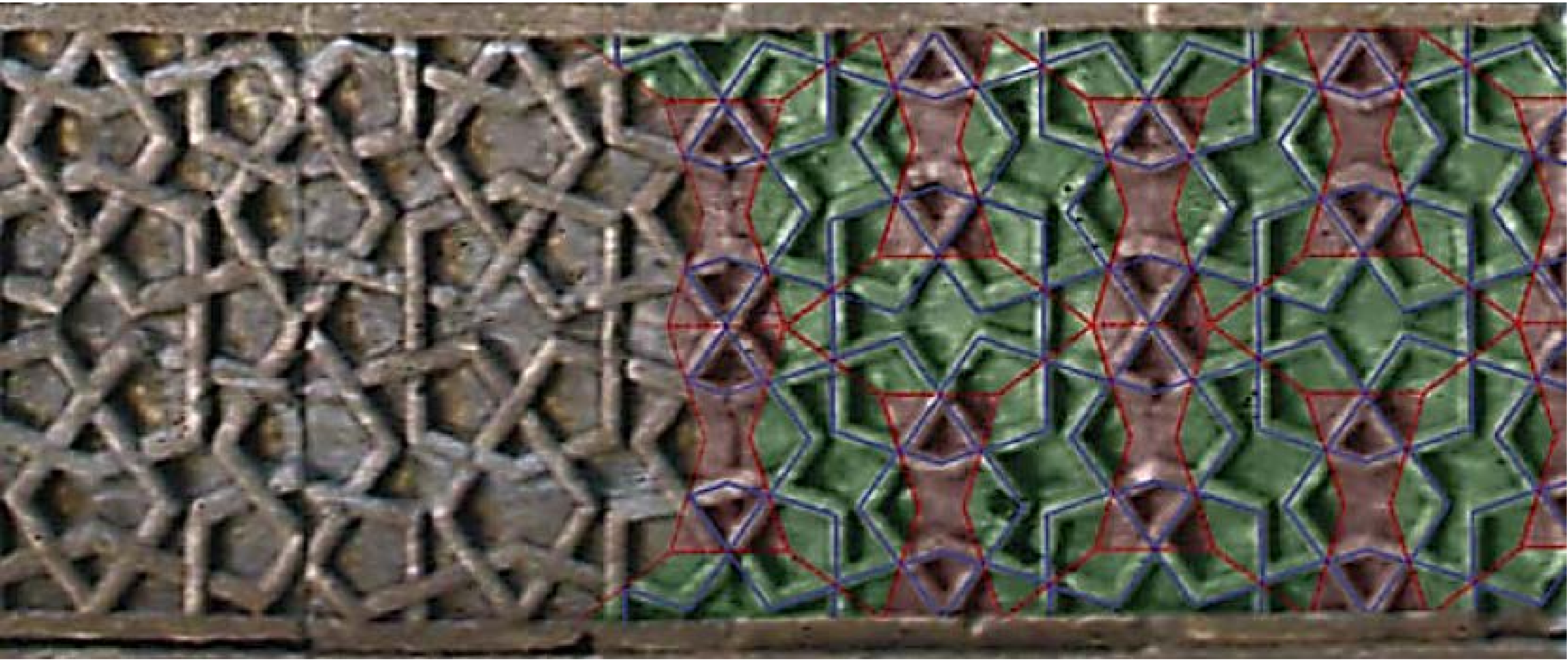


Quasi-Crystals

- Non-periodic pattern
  - Fibonacci Series
  - Penrose Tilings
- Can have rotational symmetry
- Found in nature and throughout history

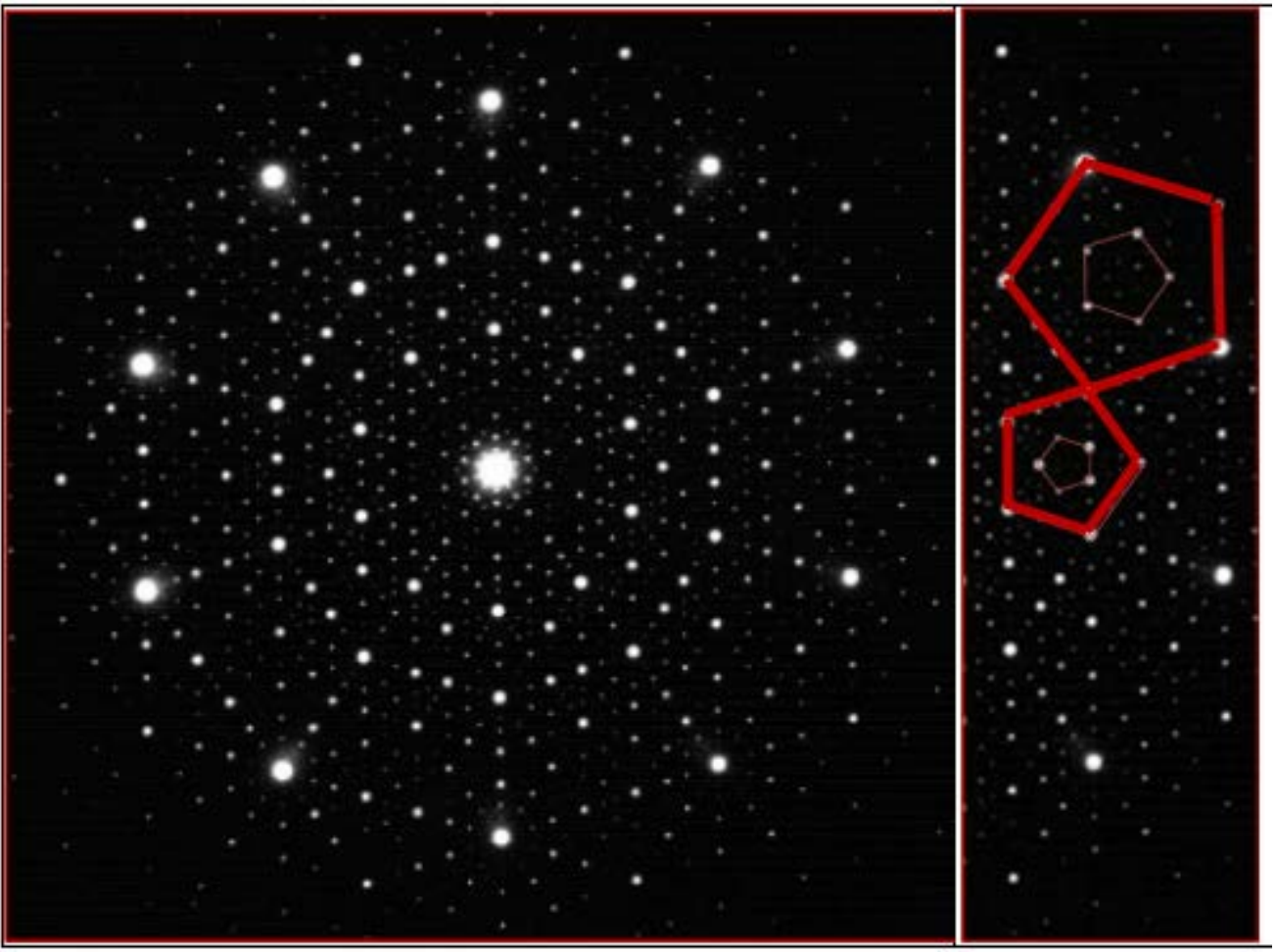


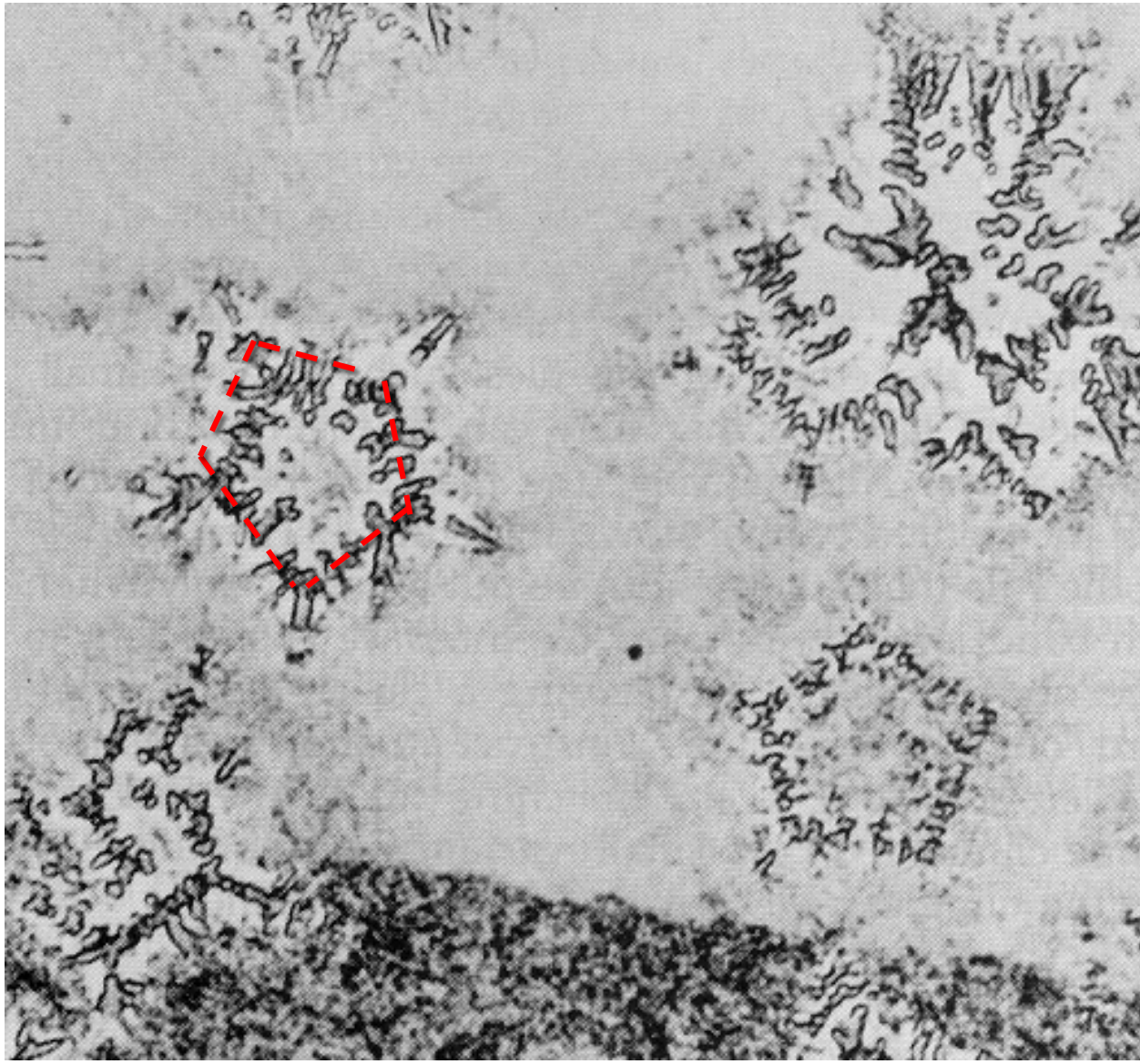




Periodic girih pattern from the Seljuk Mama Hatun Mausoleum in Tercan, Turkey (~1200 C.E.)

Al_6Mn

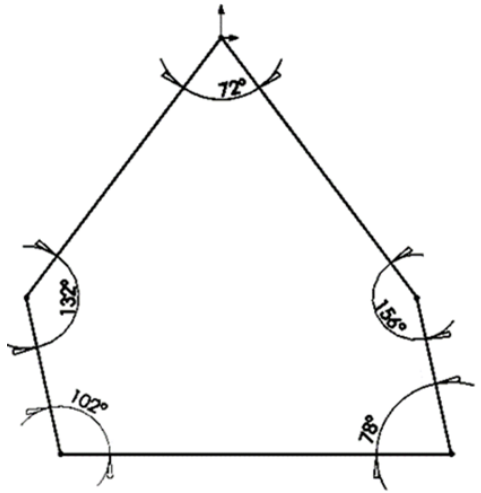


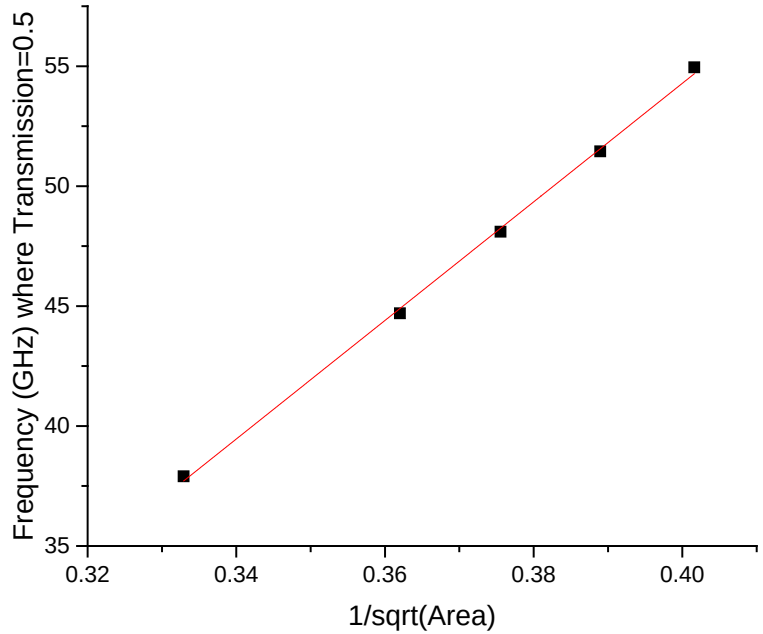


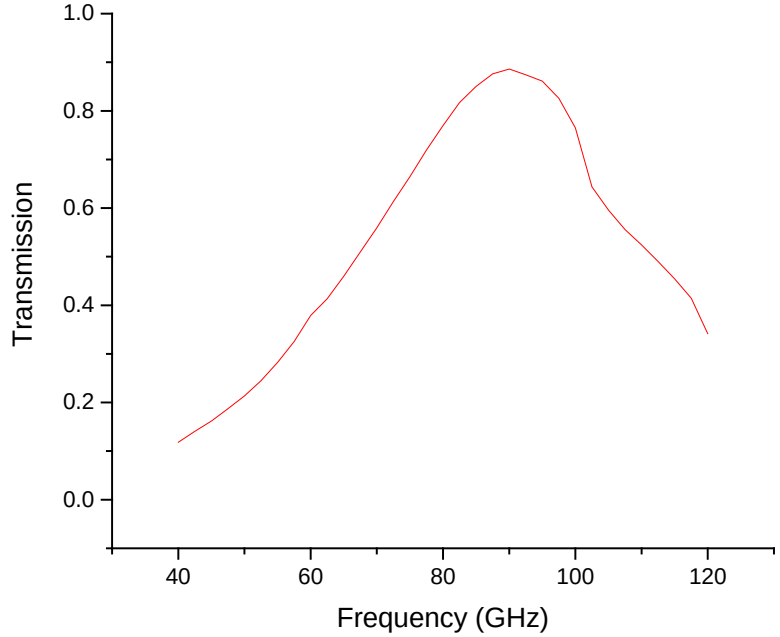
Lidin, 2011

Structure and Size

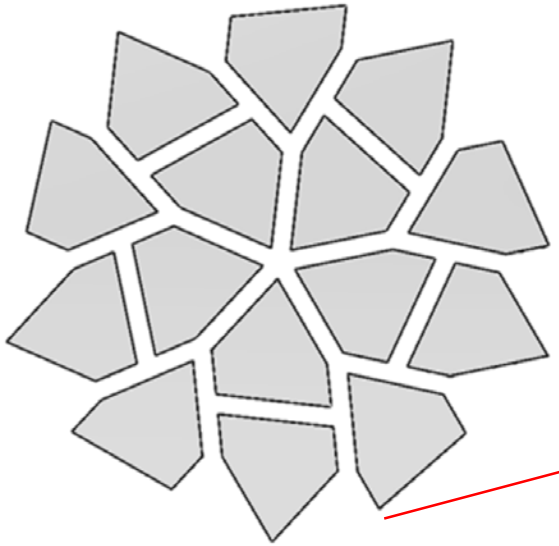
- Focused on determining the size of each unit cell
- Optical response depends on size

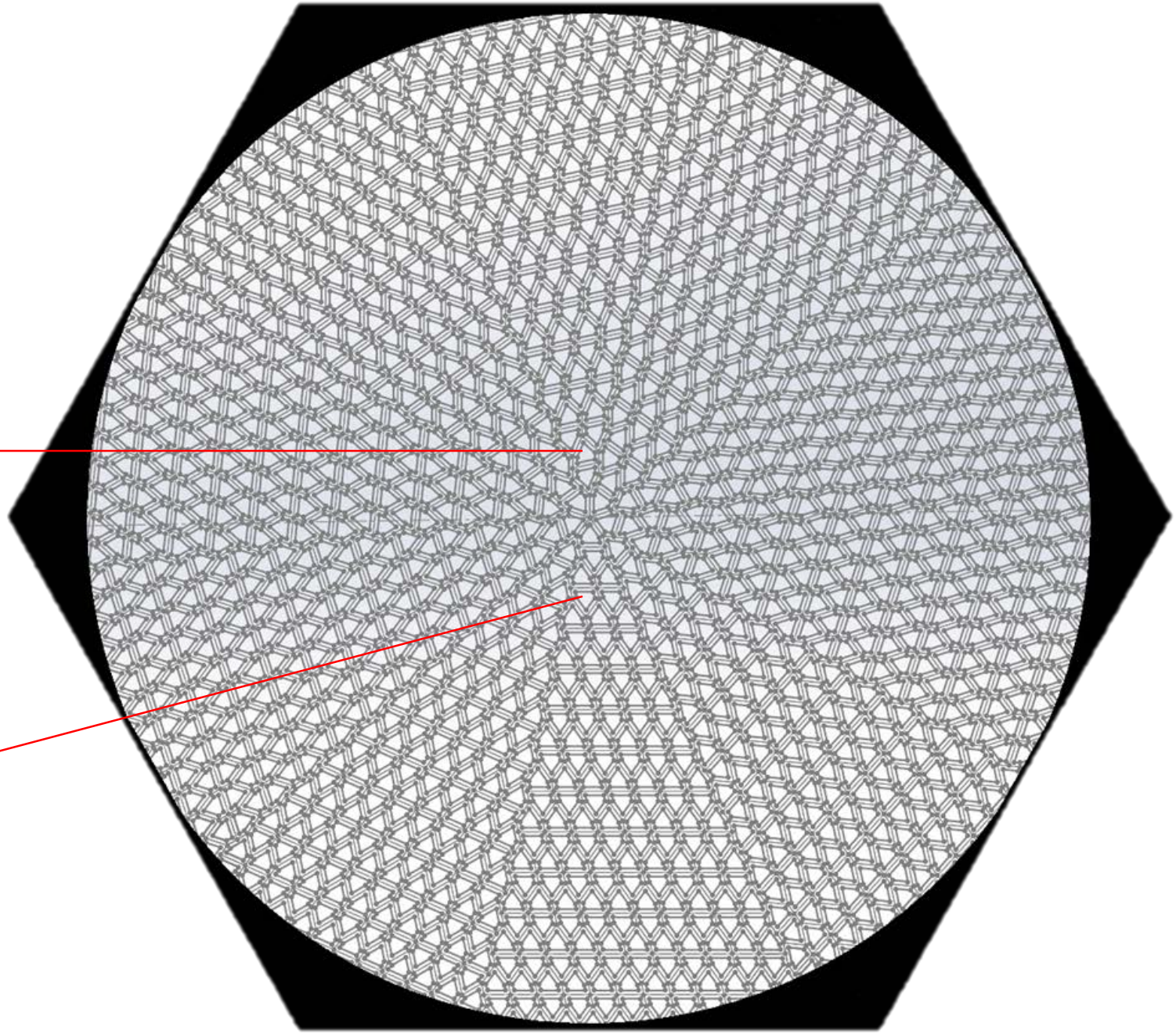






Prototype Filter





Future Work

- Fabricate quasi-crystalline filter and test in laboratory setting
- Compare performance of a quasi-periodic tiling filter structure to a Cartesian tiled filter structure
- Develop capacitive mesh complements and optimize multi layer stack for thermal blocking

Thank you!

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spedek@gmail.com

Support Slides

References and Acknowledgments

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Cartesian Tilings

- Translationally symmetric
- Same structure is periodically repeated throughout space
- One unit cell
- No gaps, holes or spaces

5-fold Symmetry

- Unable to create 5-fold symmetric Cartesian tiling
- Do 5-fold symmetric tilings exist?