Total Solar Eclipse
of
1994 November 3

taped at
La Lava, Bolivia
by

Fred Espenak

How to find loops in the solar corona

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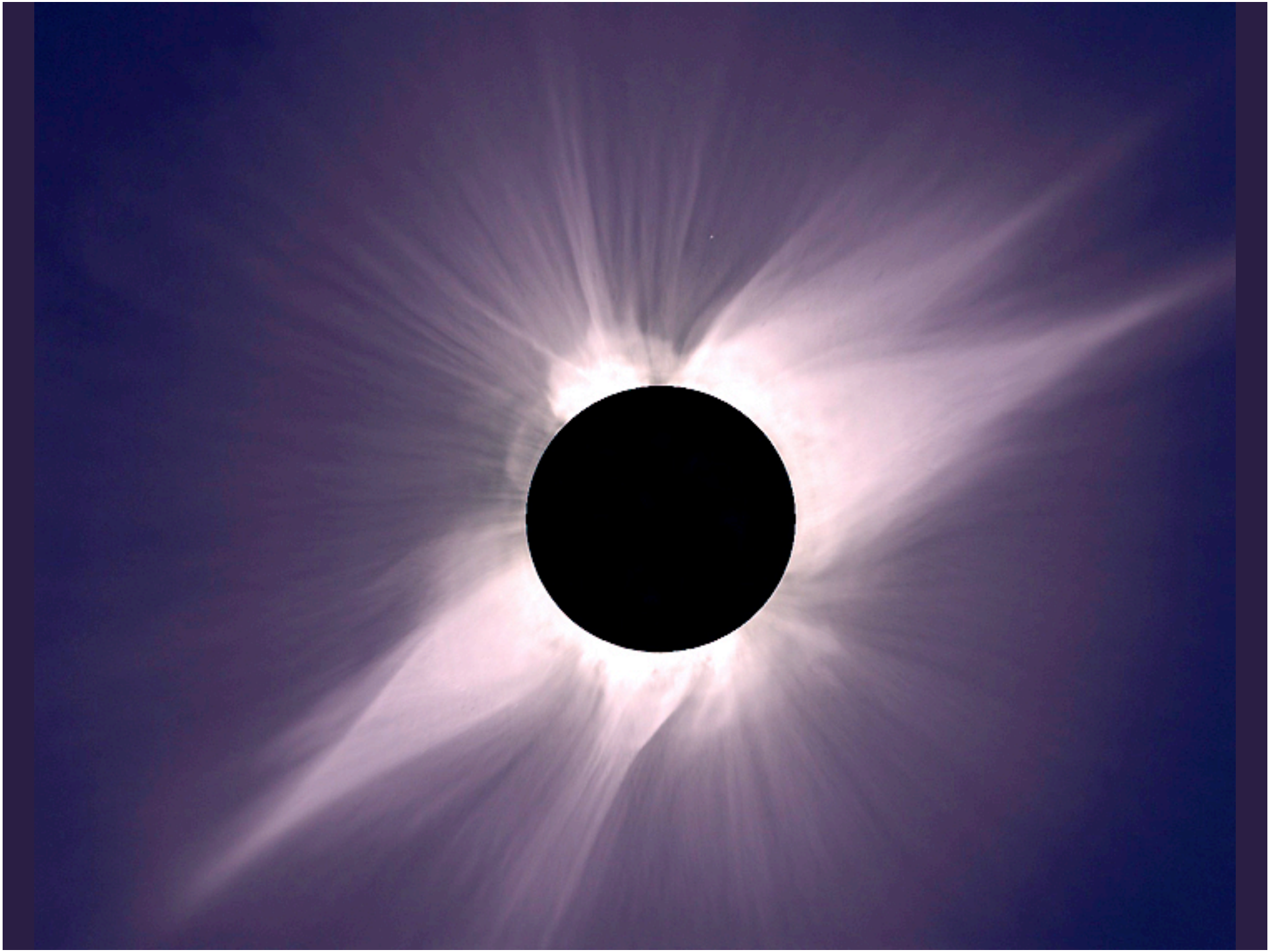


Outline

The Problem: crucial for constraining solar physics parameters

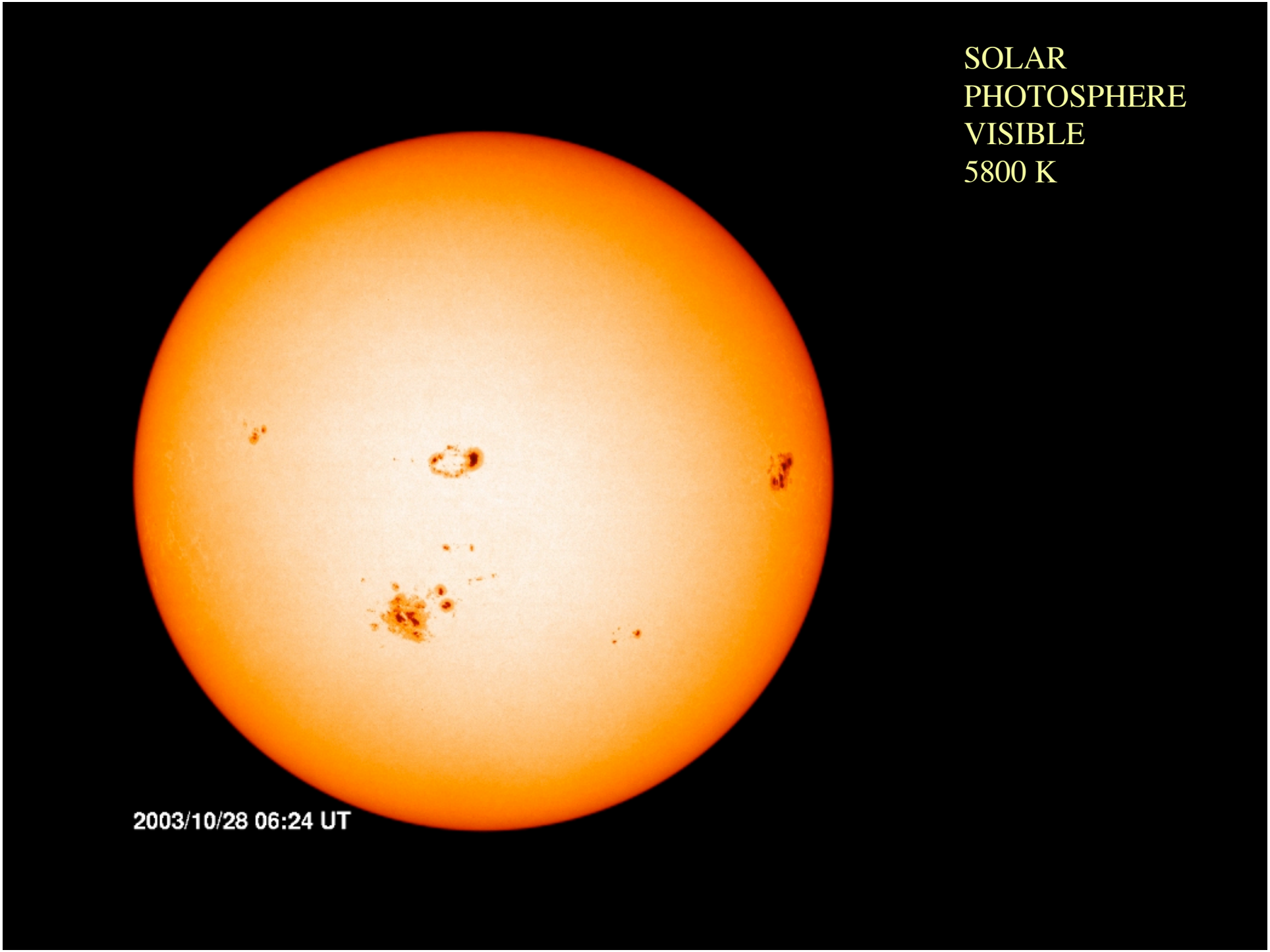
The Real Problem: loops are hard to detect objectively

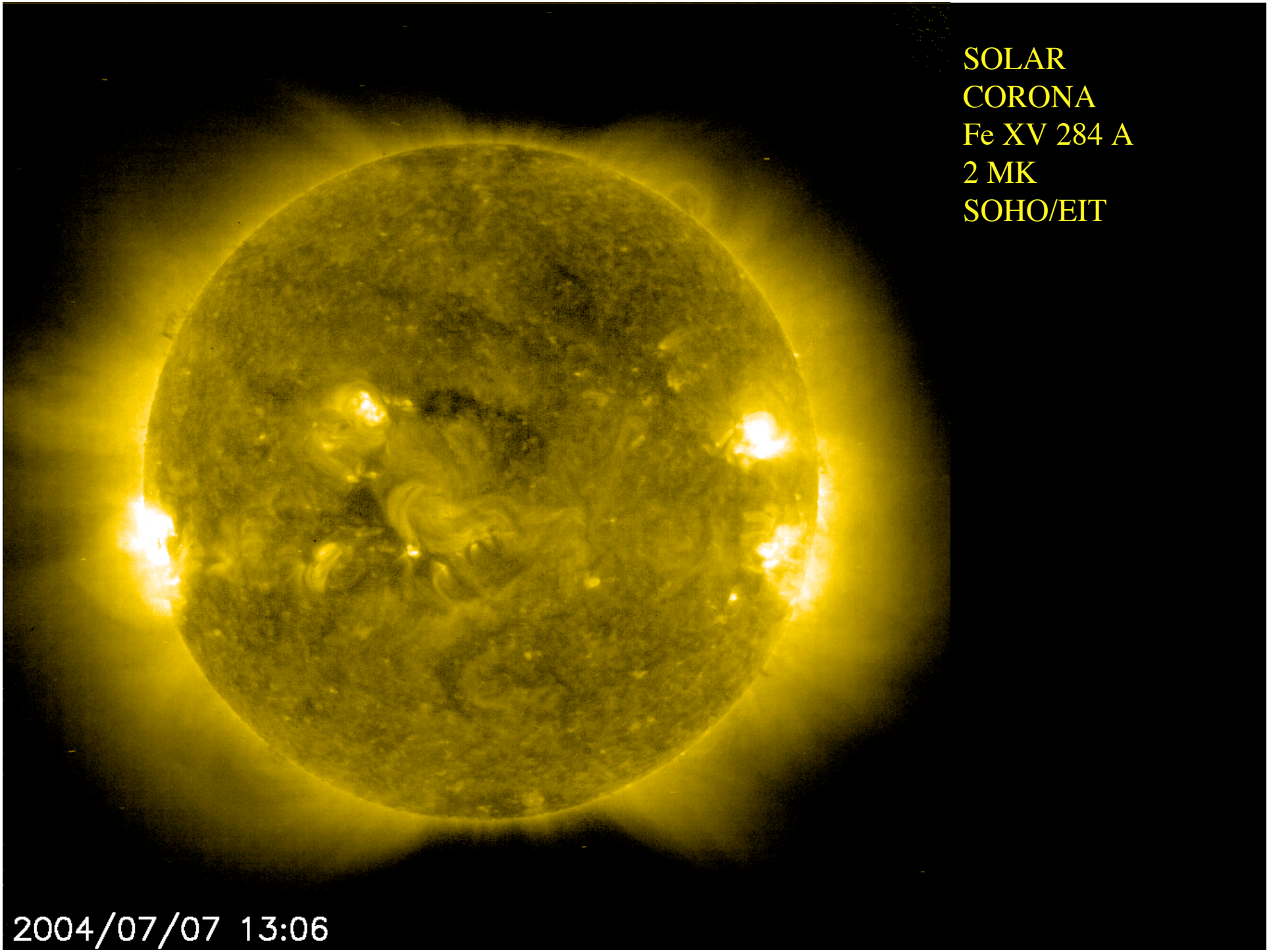
The Solution: the perfect is the enemy of the good

The Problem with the Solution

The Problem

The Solar corona is highly structured

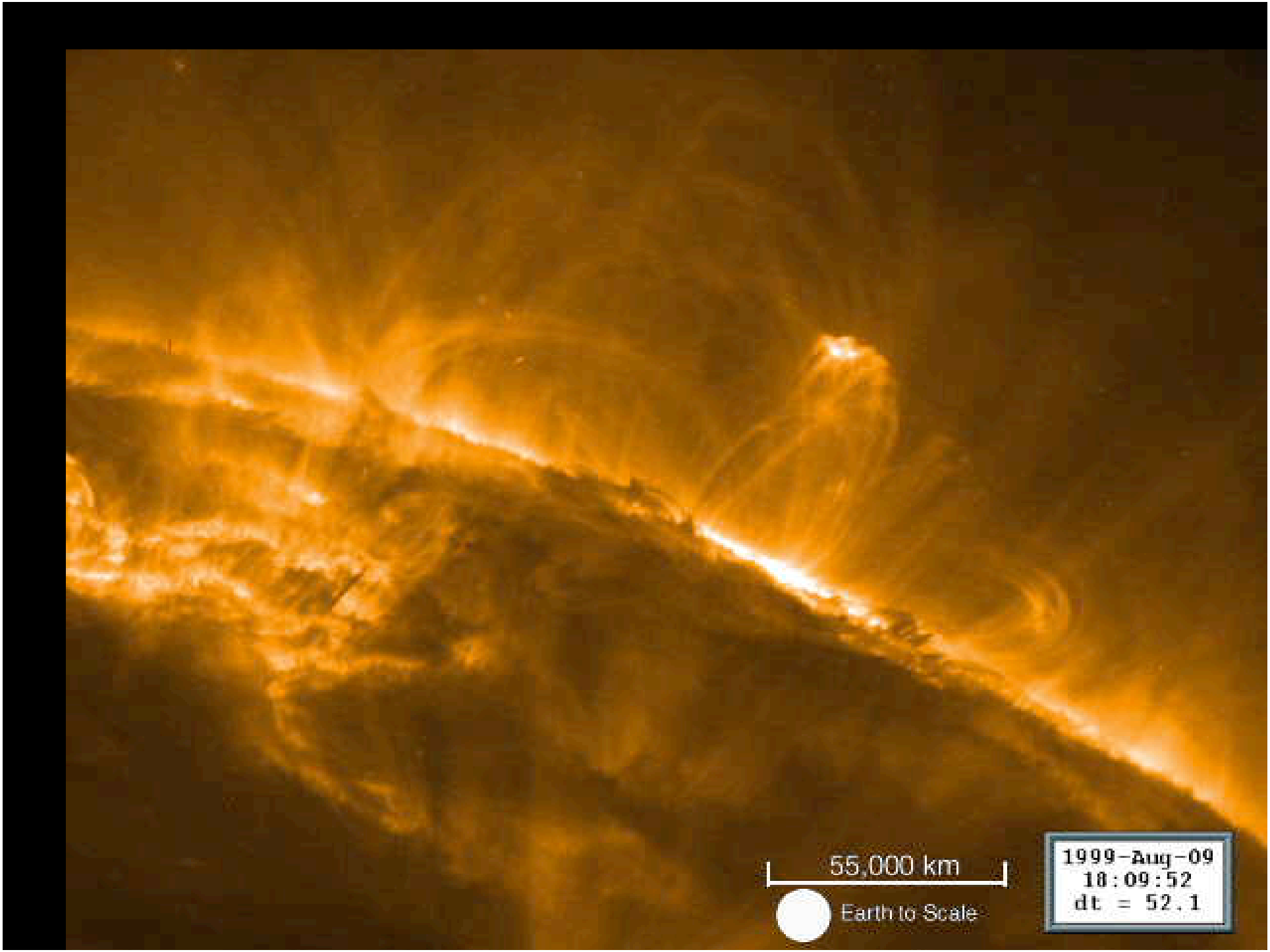

SOLAR
PHOTOSPHERE
VISIBLE
5800 K
2003/10/28 06:24 UT


SOLAR
CORONA
Fe XV 284 A
2 MK
SOHO/EIT
2004/07/07 13:06

The Problem

The Solar corona is highly structured

It is dominated by loop like structures that overlap each other


55,000 km
Earth to Scale
1999-Aug-09
10:09:52
dt = 52.1

The Problem

The Solar corona is highly structured

It is dominated by loop like structures that overlap each other

The contrast is low, and the structures are dynamic

The Practical Problem

A loop detection algorithm does not exist

Loop identification is done by “hunting and pecking”

Analyses are unstable and not reproducible

The Solution

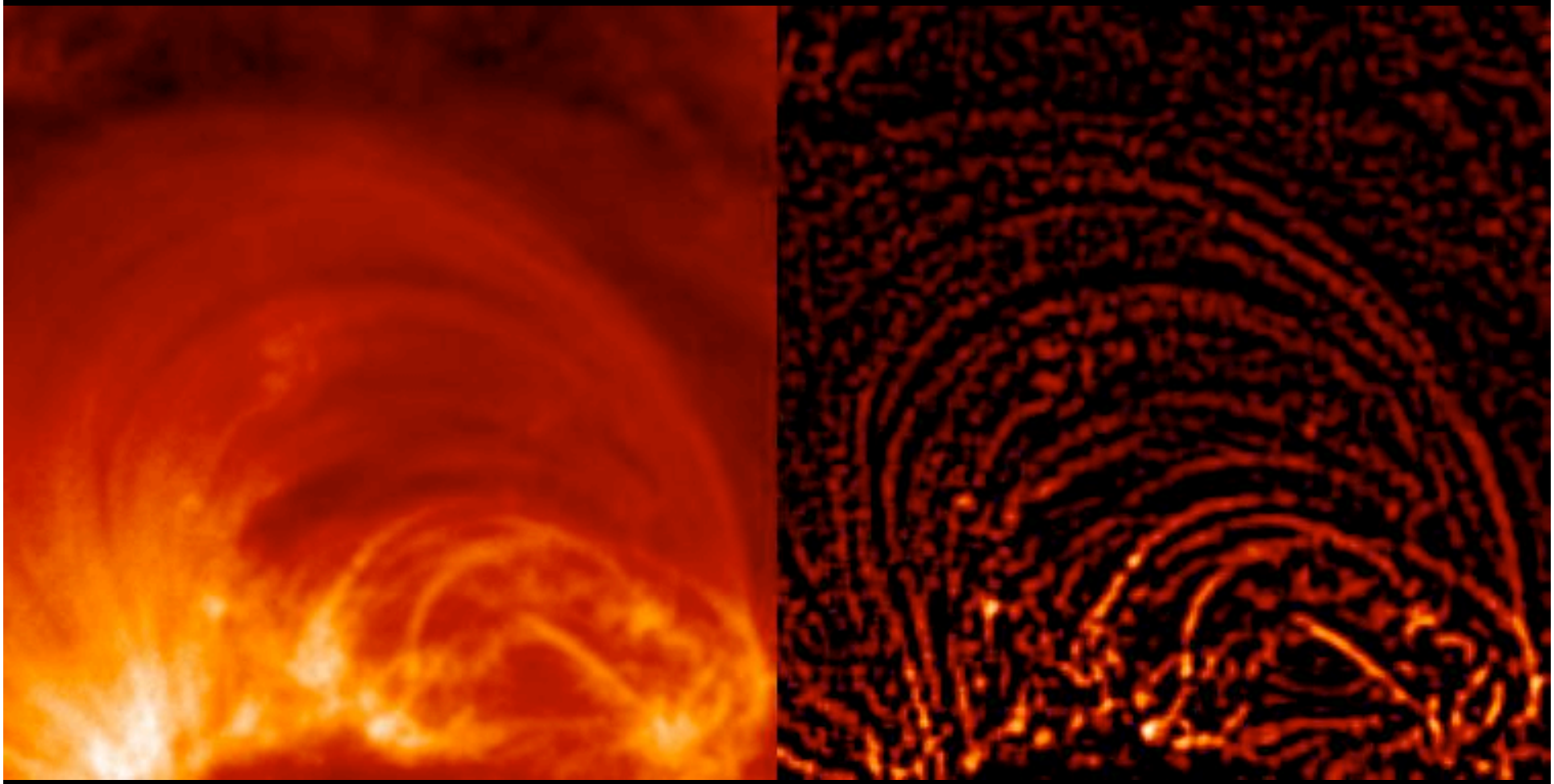
If you torture them enough, the data will confess.

Morphological processing to extract identifiable features

- enhance contrast
- morphologically open loop-like structures
- apply threshold
- group contiguous pixels into blobs
- make skeleton
- prune skeleton

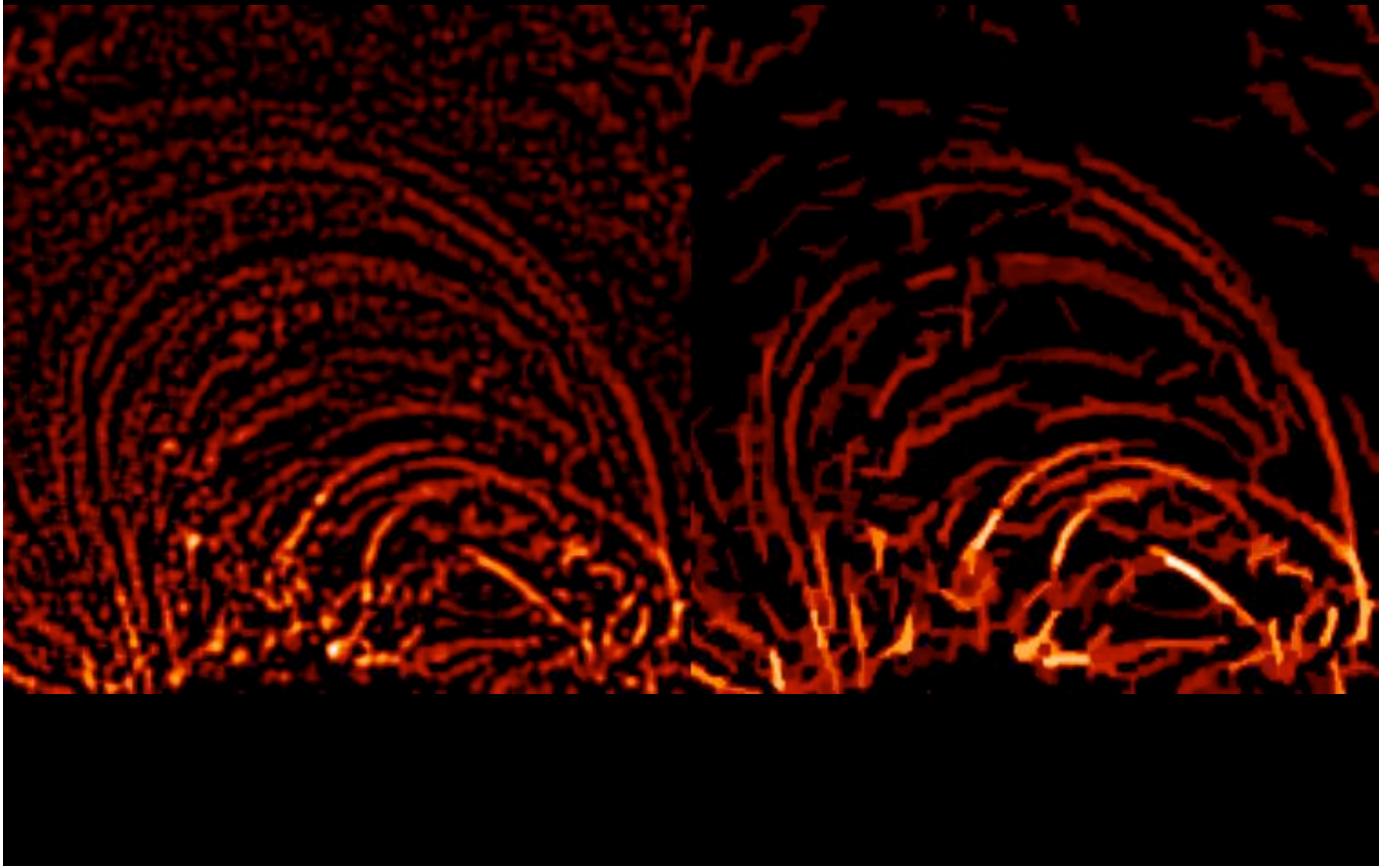
TRACE image

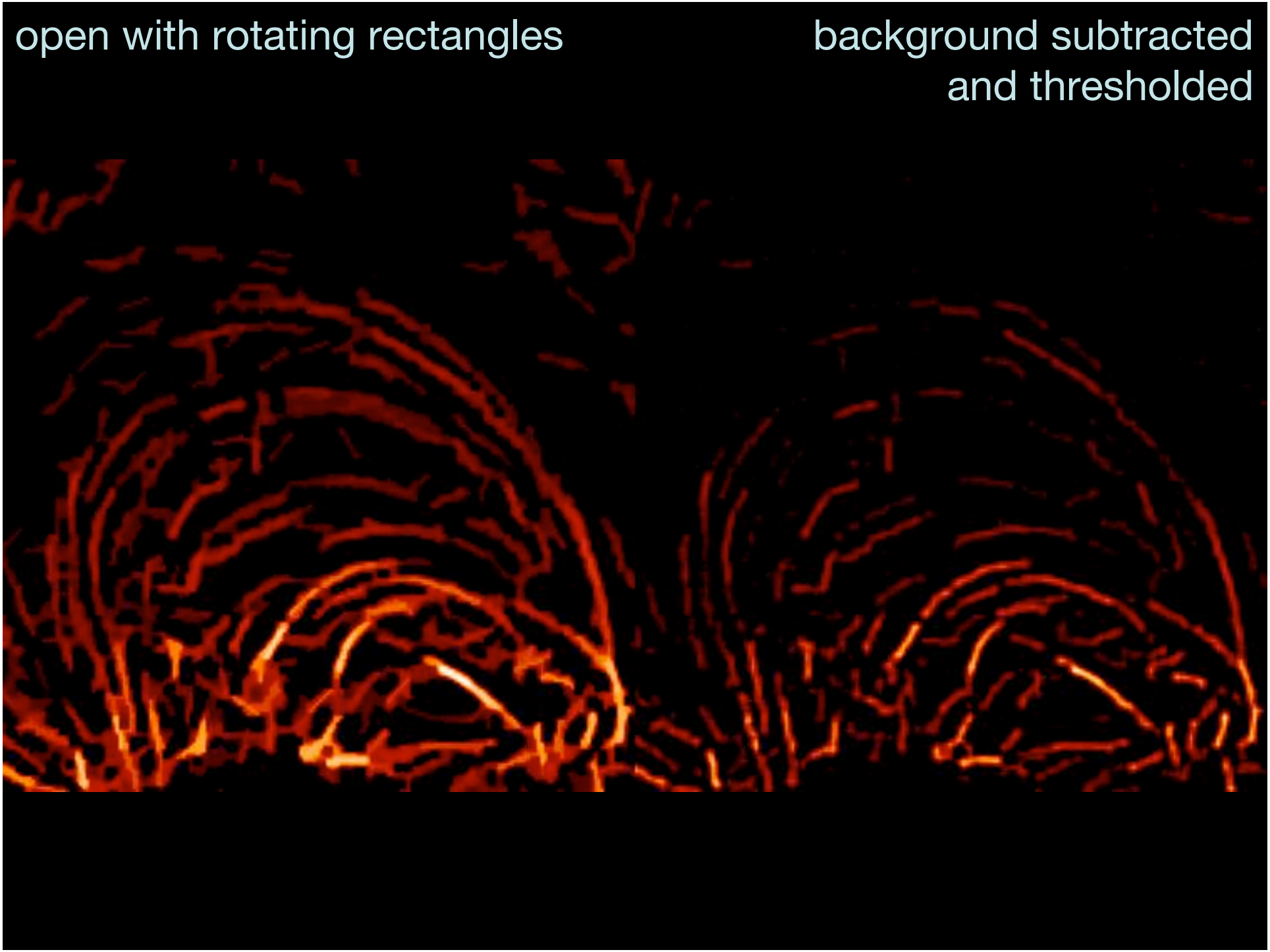
enhance contrast by
background subtraction
(like unsharp masking)

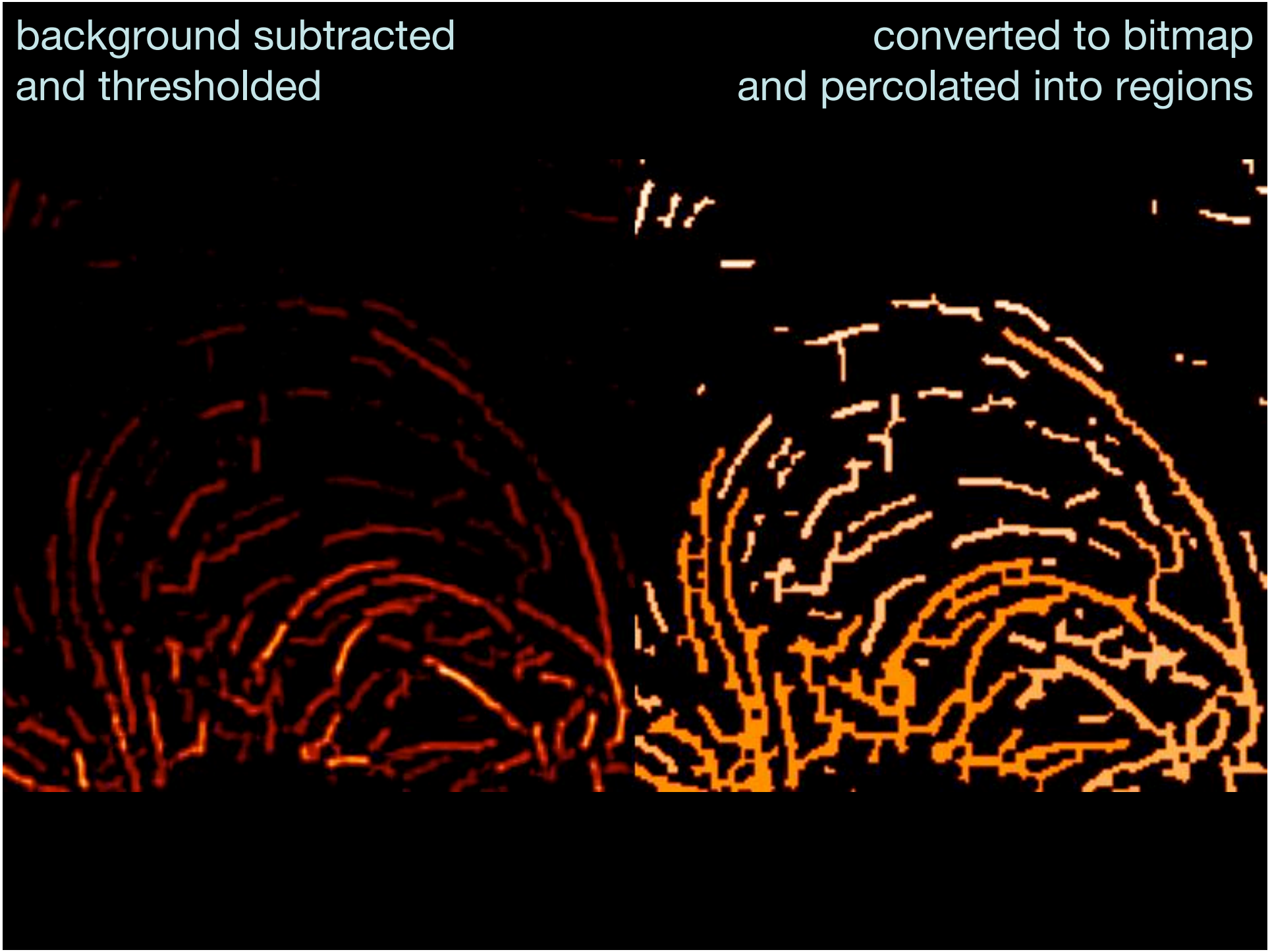


enhance contrast by
background subtraction

open with rotating rectangles

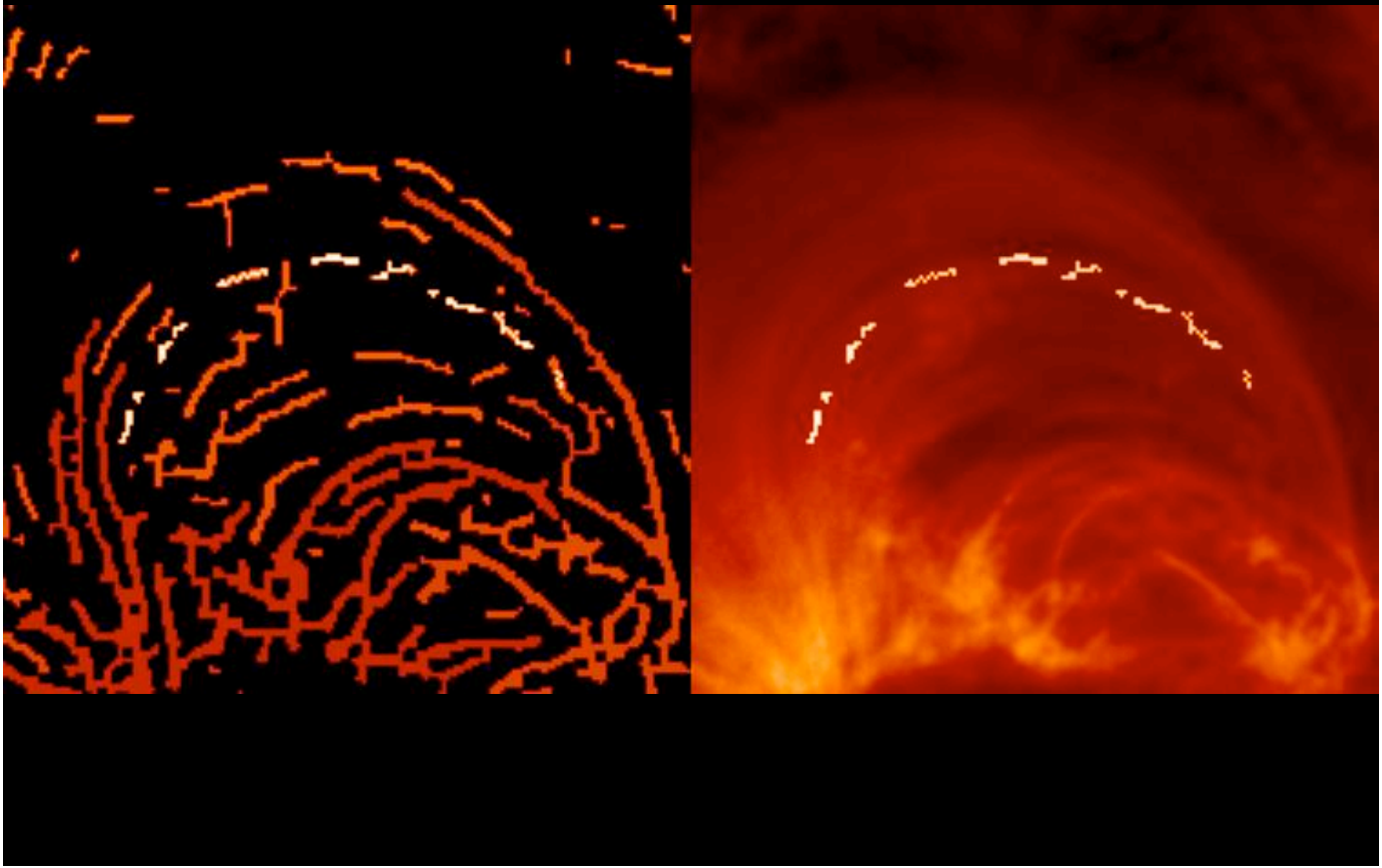


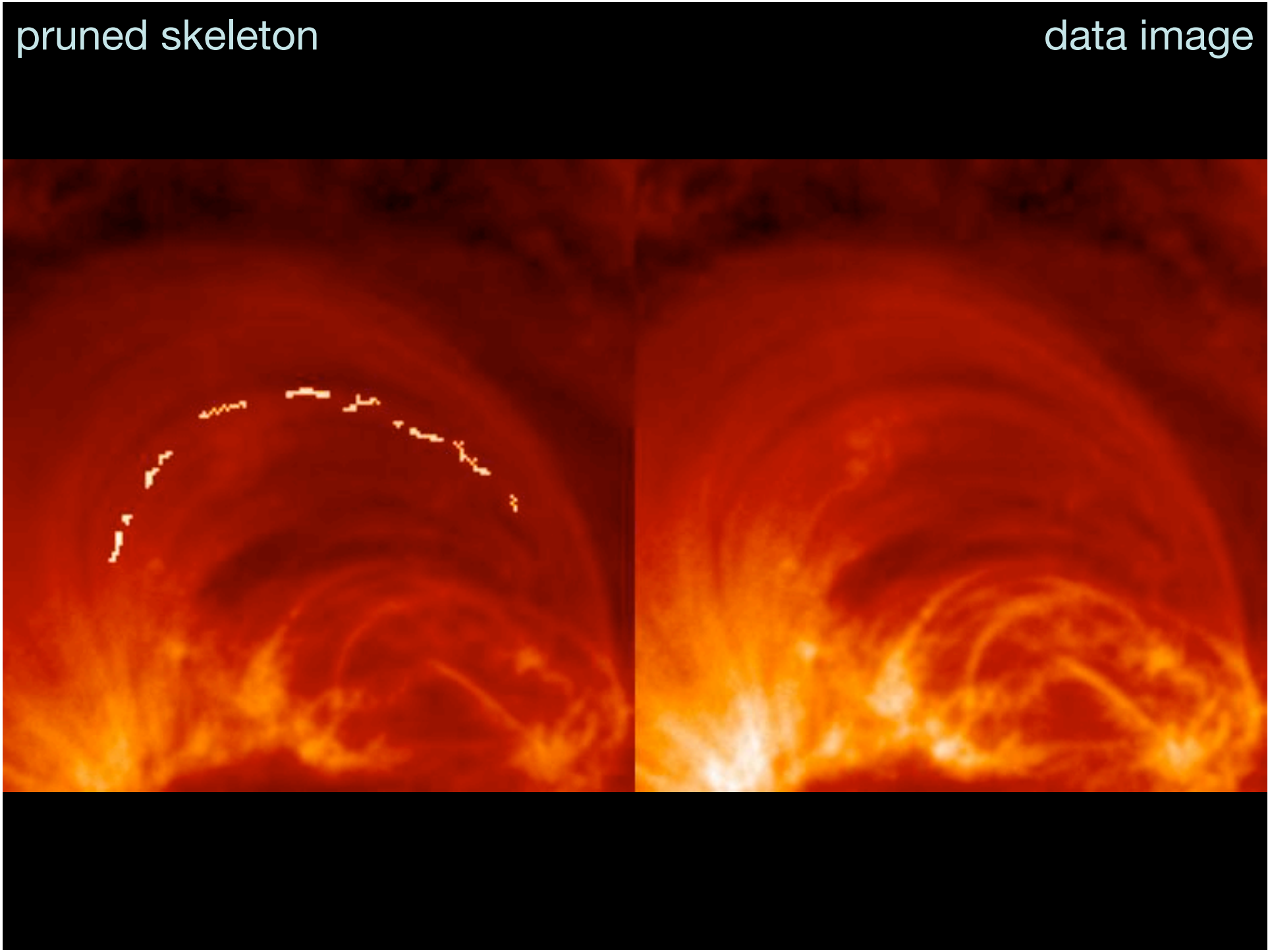

open with rotating rectangles
background subtracted
and thresholded


background subtracted
and thresholded
converted to bitmap
and percolated into regions

grouped into regions
and selected

skeleton pruned and
overlaid on data image

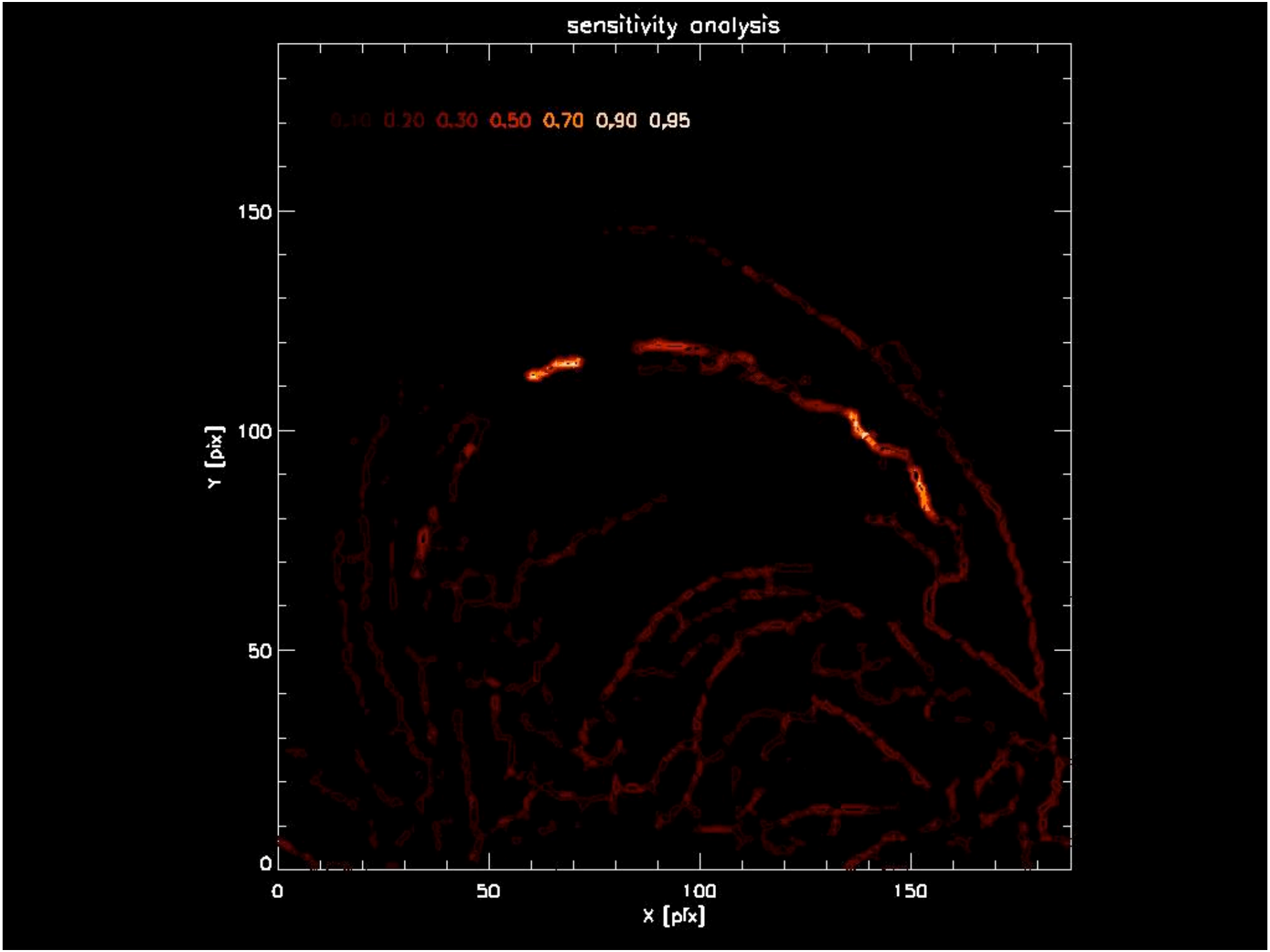



pruned skeleton
data image

The Solution

Morphological processing to extract identifiable features

enhance contrast
morphologically open loop-like structures
apply threshold
group contiguous pixels into blobs
make skeleton
prune skeleton
&
estimate error


sensitivity analysis
0.10 0.20 0.30 0.50 0.70 0.90 0.95
150
100
50
0
Y [pix]
0
50
100
150
X [pix]

In conclusion
But there are Problems with the Solution

You can only find what you already know exists

Connecting broken loop segments still requires manual intervention

Estimating the statistical significance of the detected features is rudimentary

Not necessarily the optimal heuristic

Comparing with magnetic potential field model

Loop	Emergent footpoint	Descendent footpoint	Length [10 Mm]	Temperature [K]
A	-0.23,0.49	-0.30,0.48	1.4	3.3
B	0.32,0.13	0.16,0.13	2.4	4.3
C	0.47,0.31	0.63,0.35	1.3	3.1
D	0.15,0.15	0.17,0.39	3.8	5.4
F	0.40,0.25	0.27,0.24	1.3	3.2
G	0.30,0.28	-0.04,0.12	10.8	4.5