**Introduction**

- **Motivation:**
  - A CME is an eruption of plasma and magnetic field from the sun, travelling roughly radially outwards.
  - Upon impact with the Earth, CMEs can be responsible for severe space weather effects. In particular, they can disrupt telecommunication facilities and spacecraft. As we develop more sensitive electronics here on Earth, an ability to predict both the arrival times of CMEs at Earth and their effects is of great importance.

- **Where my images come from:**
  - Onboard Coriolis, the Solar Mass Ejection Imager (SMEI) captures an image of (almost) the entire sky every 101 minute orbit. We can project this image into 2-d.

**Types of projection:**

- Hammer-Aitoff: The third gridline out from the centre represents the plane of the observer. The far left and right of the image are directly behind the observer.
- 'Fisheye': The image is projected such that the locus of points at a given elongation angle from the sun forms a perfect circle in the projection. As in the other images, the sun is blocked out in the centre.

**Problems**

- **Initial Predictions:**
  - Predicting (by hand) the arrival time of the December 2nd 2004 CME at Earth (assuming constant speed)
  - **Prediction:** 4th December 2004, 4am
  - **Actual time:** 5th December 2004, 7am
  - **Difference:** 27 hours – in total the CME took just 55 hours to reach the Earth.
  - **Looking at magnetic field data from the ACE magnometer:** the actual arrival time.
  - **Measure the CME leading edge by hand:** and (deciding whether it really is a CME) subjective.

**Solutions**

- Instead of assuming the CME travels at a constant speed, use the Tappin-Howard (TH) model.
- **Automate** the picking out of the leading edge of CMEs from SMEI image data.
- **Plot of entire CME by AiCMEs CME detection program (Max Hampson, adapted by Robin Thompson)**
- **Plot of extreme leading edge of CME** (outermost point at each P.A.)
- **Median plot** (median of outermost three points at each P.A.)
- **Mean plot** (mean of outermost two points at each P.A.)

**Automatic CME Detection**

- Raw SMEI image (May 2003)
- Plot of entire CME by AiCMEs CME detection program (Max Hampson, adapted by Robin Thompson)

**Co-ordinate Systems**

<table>
<thead>
<tr>
<th>Standard 'Fisheye' Co-ordinates</th>
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<tr>
<td>(E.A., P.A.) corresponding to (r,θ) in polar co-ordinates.</td>
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<td>E.A. - elongation angle; the angle between the sun-observer line and the CME-observer line.</td>
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<td>P.A. - position angle</td>
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**To plot, use pixel co-ordinates (x,y)**

- 5 split into quadrants
- Convert P.A.s into radians
- Use trig, e.g. in quadrant 1: $A = P.A. - 3\pi/2$
- $x = 280 + c\cos(A)$
- $y = 280 + c\sin(A)$

**Feed Leading Edges into TH**

- 3-d reconstruction of CME leading edge by Tappin-Howard model

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