Fireflies in Nature
Why Sync?

- **Selective pressure** for synchronous flashing; increased **mating success**

- Extreme “**peer pressure**” **response** for male individual flies.
Why Sync?

- Selective pressure for synchronous flashing; increased mating success
- Extreme "peer pressure" response for male individual flies.
Biological Clock Model

\[
\frac{d\theta_n}{dt} = \omega_n + a_{n,m} \sin(\theta_n - \theta_m) + \ldots
\]

\(w\): natural frequency of a firefly

\(a\): distance-dependant interaction constant

\(theta\): phase for a firefly
Synchrony Visualization
Go to Animation...
Phase Difference over Time

![Graph showing phase difference over time for syncing fireflies.](image)
Firefly Geometries: Circle

Animation Screen Cap

Circle Phase Difference

Circle Geometry Analysis

A Value (distance dependent)

Time to Sync (Sec)
Firefly Geometries: Groups
Sync Success
Dependent on Natural Frequency (omega)
Distribution Tightness

End Phase Difference Dependency on \( \omega \) Deviation

<table>
<thead>
<tr>
<th>Sigma of normally distributed ( \omega )</th>
<th>Standard Deviation of Synchronized Phase Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.1</td>
<td>0.02</td>
</tr>
<tr>
<td>0.2</td>
<td>0.04</td>
</tr>
<tr>
<td>0.3</td>
<td>0.06</td>
</tr>
<tr>
<td>0.4</td>
<td>0.08</td>
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<tr>
<td>0.5</td>
<td>0.1</td>
</tr>
<tr>
<td>0.6</td>
<td>0.12</td>
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<tr>
<td>0.7</td>
<td>0.14</td>
</tr>
<tr>
<td>0.8</td>
<td>0.16</td>
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</tbody>
</table>

\( \omega_n \) is constant
\( \omega_n \) is normally distributed with \( \text{sigma} = 1 \)
\( \omega_n \) is normally distributed with \( \text{sigma} = 5 \)
Further Applications of Syncing Models

There are many other examples of really neat spontaneous synchronization in nature:

- Migratory birds flying in tight swarms
- Schools of fish swimming in synchrony
- Heart and nervous system cell clusters

And in mechanics...
Questions?