Distribution of Young Stellar Clusters in Nearby, Grand-Design Spirals

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Outline
1) Why use NIR
2) NIR properties of clusters
3) Sample of grand-design spirals
4) Examples: NGC 1232 & 5247
5) Distribution of clusters
K-band knots in NGC 2997

- Bright knots on K-band images
  - Seen in many grand-design spirals
  - Well aligned along spiral arms
  - Marginally resolved
    - Sizes of < 50 pc
    - Cluster complexes or HII regions
  - Often embedded in dust lanes
    - Not visible on blue images
- Small size and alignment suggest
  - Dynamical young objects
  - Associated to spiral arms
K-band spectra of knots

- Observation of K-band spectra
  - ISAAC/VLT low resolution
  - 6 knots in one slit (Grosbøl et al. 2006)
- Spectral features
  - Strong Brγ emission
  - Some HeI and H2 emission
  - Stellar continuum present
- Comparison with starbust99
  - Young stellar complexes
    - Ages <10Myr
    - Embedded in HII region
HAWK-I sample of grand-design spirals

Sample of nearby, grand-design spiral galaxies
- Deep JHK photometry with HAWK-I (0.1” pixel, 7' field)
- Reasonable sample only within ~20 Mpc
- Typical seeing around 0.5” → ~50pc linear scale
  - Similar to GMC's → sources are complexes of clusters
- Complete to Mk ~ -11^m → masses down to ~10^4 Mo

<table>
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<th>Galaxy</th>
<th>Type</th>
<th>Distance Mpc</th>
<th>MBT mag</th>
<th>Scale pc/arcsec</th>
<th>S/N=5 K mag</th>
<th>Seeing arcsec</th>
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NIR colours of sources

* (H-K)–(J-H) diagram
  - Bright knots in arms are stellar cluster complexes
    - K-band spectroscopy (Grosbøl et al. 2006)
  - Photometric errors ~0.1 m
  - Stars are along stellar main sequence
  - Starburst99 models (Leitherer et al. 1999)
  - Sources with Q=(H-K)-0.59*(J-H)>0.1 m → age <10 Myr
  - Dust attenuation A_v up to 10 m
Morphology of NGC 1232

- Central bar, smooth 2-armed pattern in inner parts
- Few inter-arm cluster in region with symmetric pattern
- Multiple arms in outer regions
- Similar to the Milky Way? (Becker 64)
Distribution in NGC 5247

Morphology of NGC 5247
- Strong, open 2-armed spiral
- Few inter-arm cluster in inner parts
- More even distribution in outer regions
- Spiral perturbation stronger and more peaked than in NGC 1232
Location relative to spiral pattern

- Clusters in region of inner, symmetric pattern
  - Massive stellar cluster concentrated in arm regions
  - Clusters are brighter in NGC 5247 than in NGC 1232

![Graphs showing clusters in different regions]
Number and magnitude distributions

- Flat distribution of number of cluster with radius
  - More older clusters in NGC 1232
- Young cluster peak at brighter Mk than older ones
  - Clusters in NGC 5247 are brighter than in NGC 1232
  - NGC 5247 has bright tail of young clusters
Radial Star Formation Rate

- **Estimate of radial SFR**
  - Clusters with 0.2 < Q corresponds to ages < 7 Myr
  - Mk at $-16^m \rightarrow 10^6$ Mo (upper mass limit of clusters uncertain)
  - Radial distribution
    - Region of main, symmetric spiral is not conspicuous
    - NGC 5247 has higher rate

- **Total SFR**
  - NGC 1232: 3.8 Mo/yr
  - NGC 5247: 6.1 Mo/yr
Conclusions

- NIR protometry is required to get complete sample of massive stellar clusters in grand-design spiral galaxies.
- In region of main, symmetric spiral pattern:
  - Massive clusters are concentrated in arm regions (young and old).
    - Suggests fast destruction of these clusters.
    - No time to recreate GMC between arm encounters.
- Outer regions have more even distribution.
- Relation to spiral perturbation:
  - Spiral concentrate SF in arms but does not enhance the SFR.
  - Strong perturbation may enable creation of brighter clusters.