We report the HST/ACS photometry of M51 and NGC 5195. Two important deductions are as follows: 1) By applying offset method, the corotation radius is 40 km/s/kpc, which is essentially consistent with past determinations. However, the two main arms are both bending when CO gas and OB stars are concerned, inferring that the assumption in the offset method, i.e., long-standing wave and/or constancy of time for star formation might be inappropriate. 2) Red stars are resolved into young red-supergiants and older red-giant branch stars. They are mapped separately for the first time and we found that red-supergiants contribute significantly in luminosity in the star-forming regions, indicating that simple surface brightness distribution in red do not necessarily indicate the distribution of old stars and thus the gravitational potential.

**Data**

- NASA/HST Heritage program (ID 10452, PI: S.V.W. Beckwith)
- Image: obtained on Jan 2005 (15th anniversary of HST); archived on Apr 2005
- HII distribution: High-Level Science Product via MAST/STScI (Mushlly+09)
- Area: 6 ACS/WFC2 mosaic on M51-NGC1365 (fores region, except the two main arms)
- Size: 430’×610’; 860pix×1220pix, 350MB each
- Pixel scale: 0.05 arcsec/corresponding to 2.3pc at M51, assuming 9.6Mpc
- Bands: F438W(B), F555W(V), F606W(I), F660N(W), with a FWHM of 0.1’
- Exposure : 4 exposures for each mosaicing tile
- Limiting magnitude (Vega): B − 26.5, I − 25.3
- Angular offset: d(HII region) = [V(r) − I(r)] × σp (σp: time for star-formation)
- Assumptions: We expect a linear regression (Fig. 2), if: 
  - qp is constant long-standing arm of the density wave (DW theory)
  - qp is constant
  - Choice of the tracer (Louis+13)
  - Location of gas compression: IL CO
  - Location of star-formation: HII emission, 24 μm emission
  - Louis+ (2013) concluded that CO (Gas) and H2 (FIR) are the best.
  - We use OB stars (SFR for the first time; independent reliable measure of time/scale limit, ample in number (but, still the largest error source))
- Pattern speed (Fig. 3)
  - qp ~ 40 km/s/Mpc; c_oscillation ~ 6 kpc
  - 2nd arm is not used beyond 4 kpc (strong pull of N5195 would deform the structure)
  - Consistent with past results (Egusa+ 09); consistent with structure that no strong gas emission and no prominent arm beyond this radius
- Diagnostics of the disk
  - Obviously nonlinear q T θ relation; Strong dip at 2−3 kpc in two main arms

**Future Work**

- Apply TW method for radial dependence of pattern speed.
- Ha business: dependence of strongemg radius on location.
- Ha business: Classification of PN, Be stars, and so on.

**Archaeology**

- We superposed isochrones (Girardi+2002), with m−M = 29.91 (9.6 Mpc), and A_V = 0.12, A_I = 0.07 (Fig. 4).
- MSTD: log t(δyrs) = 7.8
- RGB: log(δyrs) > 7.8
- V−I < 0.5 & I−K > 2 are star clusters etc.
- SFRs are rich in red-supergiants (RGB). The distribution of RGB (V−I > 1.0 & I−K > 2.5) traces SFRs (Fig. 5), and RSG contribute by 15% at least in I-band (this is a significant underestimate, Fig. 6). Surface brightness in red or even infrared may still suffer from RSG and not stand for old stars that follow the gravitational potential.
- The distribution of RGB stars shows a density contrast of ~3 between arm and interarm region. Deeper photometry is necessary to finalize this important factor.

**Conclusion**

- A photometric catalog of M51 and NGC 5195 is constructed based on HST/ACS/WFC2 heritage observation.
- It is found that pattern speed is ~ 40 km/s/kpc and corotation radius ~ 6 kpc: confirming the results from HII regions.
- However, q T θ relation is non-linear and constancy of star-formation time-scale and/or density wave theory (long-standing arm) may not be the case.
- Red-supergiant stars are rich in the star-forming regions, enough to contribute more than 20% in the F band luminosity.