Starbursts

From 30 Doradus to Lyman Break Galaxies

Late Abstracts

Westerlund 1: A Super-Star Cluster within the Milky Way

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We present optical and IR photometric and spectroscopic observations of the young open cluster Westerlund 1 (Wd1) which indicate it is the first Super Star Cluster identified in the Milky Way. Wd1 hosts a rich population of OB supergiants, Wolf-Rayet stars, Luminous Blue Variables, Yellow Hypergiants and Red Supergiants, from which we infer an age of 5 Myr. For an adopted Kroupa IMF we derive a mass of 10^5 $M_\odot$ and radius of 0.2 pc for an estimated distance of 2.5 kpc. As such, Wd1 is the most massive, and densest, young cluster in the Local Group, exceeding NGC 3603 and the Arches cluster in the Milky Way and R136 in the LMC.

Star Formation in Close Pairs Selected from the Sloan Digital Sky Survey

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The effect of galaxy interactions on star formation has been investigated using Data Release 1 of the Sloan Digital Sky Survey (SDSS). Both the imaging and spectroscopy data products have been used to construct a catalogue of nearest companions to a volume-limited ($0.03 < z < 0.1$) sample of galaxies drawn from the main galaxy sample of SDSS. Of the 13973 galaxies in the volume-limited sample, we have identified 12492 systems with companions at projected separations less than 300 kpc. Star-formation rates for the volume-limited sample have been calculated from extinction and aperture corrected Hα luminosities and, where available, IRAS data. Specific star-formation rates were calculated by estimating galaxy masses from z-band luminosities, and r-band concentration indices were used as an indicator of morphological class. The mean specific star-formation rate is significantly enhanced for projected separations less than 30 kpc. For late-type galaxies the correlation extends out to projected separations of 300 kpc and is most pronounced in actively star-forming systems. The specific star-formation rate is observed to decrease with increasing recessional velocity difference, but the magnitude of this effect is small compared to that associated with the projected separation. We also observe a tight relationship between the concentration index and pair separation; the mean concentration index is largest for pairs with separations of approximately 75 kpc and declines rapidly for separations smaller than this. This is interpreted as being due to the presence of tidally-triggered nuclear starbursts in close pairs. Further, we find no dependence of star-formation enhancement on the morphological type or mass of the companion galaxy.

Control of Star Formation in Galaxies by Gravitational Instability

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We present high-resolution (up to 3 million particles) simulations of star formation for a wide range of disk galaxies consisting of a dark matter halo, a stellar disk, and isothermal gas. We use a three-dimensional, smoothed particle hydrodynamics (SPH) code implemented with sink particles, which represent collapsing star clusters. Our results show that, both the global Schmidt Law for star formation (Kennicutt 1998), and the star-formation threshold (Martin & Kennicutt 2001), can be reproduced excellently by gravitational collapse and an isothermal EOS, suggesting that the dominant physical mechanism determining the star-formation rate is just the strength of the gravitational instability. We find a strong correlation between star formation and the value of the Toomre instability parameter Q for stars and gas together (Rafikov 2001): the star-formation rate (SFR) decreases exponentially with Q. This suggests that vigorous starbursts occur where Q is small, while quiescent star formation takes place where Q is large. Massive galaxies, or galaxies with large gas fractions, tend to have low initial Q (smaller than unity), which leads to fast star formation in a very short time; while low-mass galaxies, or galaxies with small gas fractions, tend to have high initial Q, which maintains slow star formation over a long time. Q increases as the galaxies evolve. Feedback from massive stars probably increases Q and speeds up the cut-off of star formation.

Formation of Globular Clusters in Galaxy Mergers

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We present a high-resolution simulation of globular cluster formation in a galaxy merger. For the first time in such a simulation, individual star clusters are directly identified and followed on their orbits. We quantitatively compare star formation in the merger to that in the unperturbed galaxies. The merging galaxies show a strong starburst, in sharp contrast to their isolated progenitors. Most star clusters form in the tidal features. With a mass range of $5 \times 10^5 - 5 \times 10^6$ $M_\odot$, they are identified as globular clusters. The merger remnant is an elliptical galaxy. Clusters with different mass or age have different radial distributions in the galaxy. Our results show that the high specific frequency and bimodal distribution of metallicity observed in elliptical galaxies are natural products of gas-rich mergers, supporting a merger origin for the ellipticals and their globular cluster systems.

The Rest-Frame FUV Morphologies of Star-Forming Galaxies at $z \sim 4$ and $z \sim 1.5$

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We apply a new approach to quantifying galaxy morphology and identifying galaxy mergers to the rest-frame far-ultraviolet images of 71 $z \sim 4$ Lyman break galaxies and 55 $1.2 < z < 1.4$ galaxies in the GOODS and Ultra Deep Fields. We compare the morphological distributions of the Gini coefficient (G), second-order moment of the brightest 20% of galaxy light (M_{20}), and concentration (C) for high-z and low-z galaxies with average S/N per pixel of > 2.5 and Petrosian radii $> 0.3''$. We find no strong morphological differences between the fainter UDF LBG sample and the brighter GOODS LBG samples nor between the $z \sim 4$ LBGs and the $z \sim 1.5$ galaxies. Ten of the 71 LBGs have $M_{20} > -1.1$ and possess bright double or multiple nuclei, implying a major-merger fraction $\sim 14\%$. Galaxies with bulge-dominated morphologies ($G > 0.55, M_{20} < -1.6$) make up 31–43% of the $z \sim 4$ sample, while the remainder have G and M_{20} values higher than expected for smooth bulges and disks. We have also examined the rest-frame FUV $-B$ colors ($i - K$ for $z \sim 4$ and $B - J$ for $z \sim 1.5$) as a function of morphology for a subset of both samples. The rest-frame FUV $-B$ colors show no strong correlations with galaxy morphology.

Secular Evolution of Stellar Bars, Vertical Instabilities and Starbursts

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Vertical instabilities, buckling, in stellar bars weaken and shorten the bar. This can interrupt the bar-induced gas inflow into the central kpc of a galaxy for ~ 1 Gyr. The subsequent bar growth in length and in amplitude can lead to a recurrent buckling. The first buckling results in the formation of a peanut/boxy-shaped bulge when viewed edge-on, and the second buckling forms an X-shaped bulge. The secular growth of the bar and the recurrent buckling can lead to important observational corollaries in bar fraction, bar detection, offset dust lanes, bar size-to-corotation ratio, etc.

Are Gamma Ray Bursts Good Star-Formation Indicators?

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Since long-duration GRBs are associated with the deaths of massive stars, they are also indicators of star-formation activity. Advantages they have over conventional methods are that they are extremely bright, and hence visible to high redshifts, and detectable in gamma-rays through very high columns of dust and gas. If they are unbiased tracers of star-formation activity, then the GRB host galaxies should contain all populations of star-forming galaxies, in proportion to their contribution to the global star-formation rate. In particular, if a high proportion of star formation occurs in obscured mode, then a similar proportion of GRBs and their hosts should also show signs of dusty environments. We describe progress towards testing this prediction.
