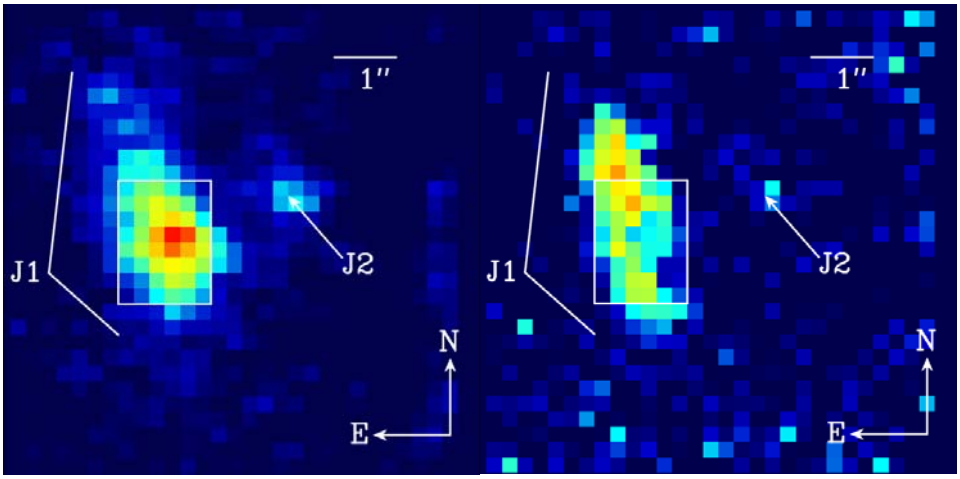
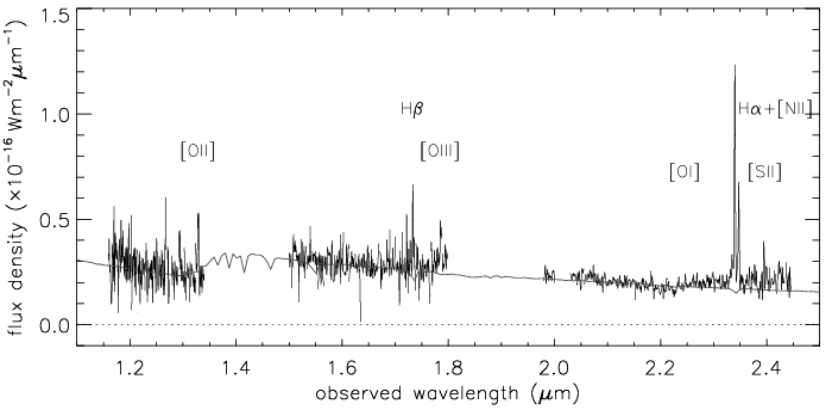
SPIFFI Observes an Old, Fat, and Rich Starburst

The SPectrometer for Infrared Faint Field Imaging (SPIFFI) has been used to obtain J, H, and K band integral field spectroscopy of the z = 2.565 luminous sub-millimeter galaxy SMM J14011+0252. The brighter of this system's two components proves to be an intense starburst remarkably old, massive, and metal-rich for the early epoch at which it is observed.



8"x8"images of line-free K-band continuum (left) and continuum-subtracted H_α line emission (right). Molecular gas and dust emission peak between components J1 and J2 (Ivison et al. 2001; Downes & Solomon 2003). The box indicates the aperture used to extract the spectrum shown below. For details, see Tecza et al. (2004, ApJ, 605, L109).

SMM J14011+0252 was one of the first submillimeter galaxies (SMGs) to have an optical counterpart identification (Barger et al. 1999) validated by CO interferometry (Frayer et al. 1999). Because it lies behind the z = 0.25 cluster Abell 1835, it is gravitationally lensed; however, spatially resolved maps of its CO emission have led to quite different conclusions about whether it is a weakly magnified large source (Ivison et al. 2001) or a strongly-magnified small source (Downes & Solomon 2003). Our SPIFFI observations have for the first time separated the system's line and continuum emission, revealing quite different morphologies (above). A global spectrum of component J1 (below) shows a strong continuum break between J and H bands, which can best be explained as the Balmer break of a z~2.5 stellar population that has been forming for ≥100 Myr. The line fluxes imply (via the locally calibrated R_{23} estimator) an oxygen abundance that is supersolar by ~0.3 dex. This abundance, the ~1.6×10^{10} $M_\odot$ of gas still remaining, and a closed-box enrichment model imply a total baryonic mass ~7.9×10^{10} $M_\odot$, consistent with the local mass--metallicity relation (Tremonti et al. 2004). This result offers independent confirmation of the proposition that SMGs have much larger baryonic masses than typical UV-selected galaxies at the same epoch (Genzel et al. 2003).



Estimated global parameters:
- **magnification ~ 5**
- **gas mass ~ 1.3×10^{10} $M_\odot$**
- **stellar mass ~ 6.6×10^{10} $M_\odot$**
- **stellar age ~ 220 Myr**
- **star formation ~380 $M_\odot$ yr^{-1}**
- **metallicity ~ 1.9 $Z_\odot$**

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