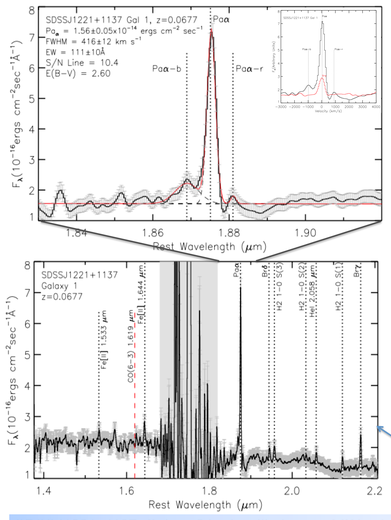
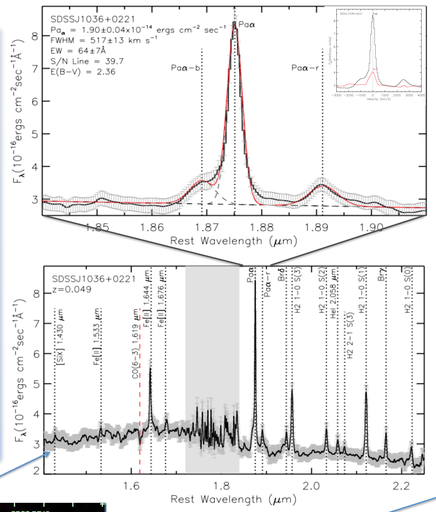
# A Near-Infrared Spectroscopic Analysis of Galactic Mergers: Revealing Obscured Accretion

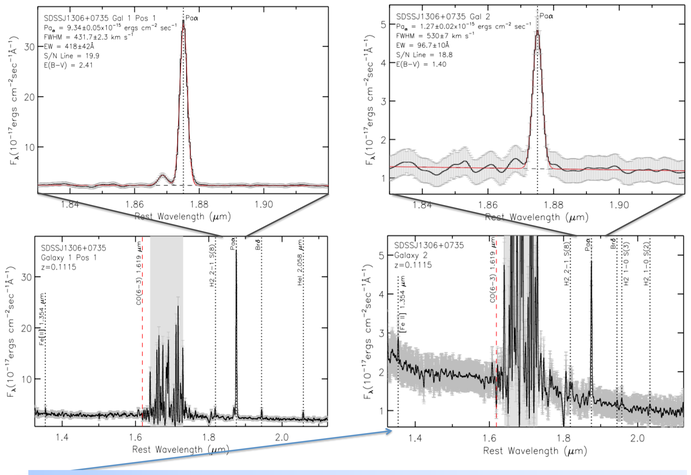
**Jason Ferguson** (JMU), Anca Constantin (JMU), Shobita Satyapal (GMU), Barry Rothberg (LBTO, GMU)



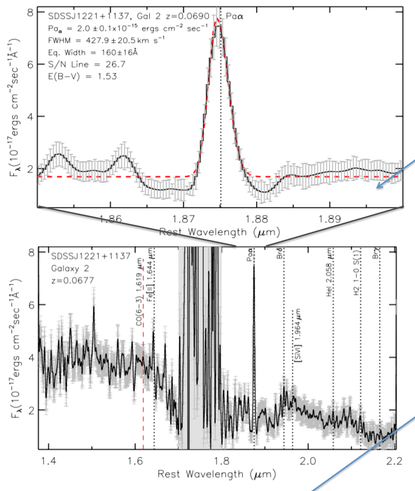

Galaxy interactions are ubiquitous and are believed to play a pivotal role in the formation and evolution of galaxies via facilitating gas inflows toward the central region of galaxies. These interactions are potentially triggering accretion of matter onto the central supermassive black holes, which are observed as Active Galactic Nuclei, or AGNs. Despite decades of searching, dual AGNs remain extremely rare, with only a handful of such systems that have been confirmed observationally. Conceivably, optical detection of dual merger-induced AGN is hampered by dust obscuration or contamination of the observed nuclear emission by the host galaxy. We present here a thorough near-infrared characterization of six examples of interacting galaxies with unambiguous confirmation of on-going mergers that are optically quiescent (i.e., show no sign of black hole accretion activity in their optical nebular emission) but have red mid-infrared colors that are associated with extragalactic sources with powerful AGN (Satyapal et al. 2014). We show spectra of nuclear regions obtained with the *Large Binocular Telescope* Near-Infrared Utility with *Camera and Integral Field Unit for Extragalactic Research* (LUCIFER; Seifert et al. 2003, 2010) which covers an observed wavelength range of approximately 1.4-2.2 micrometers. These observations reveal a rich variety of emission and absorption features that allow us to explore several diagnostic tests for the AGN activity as well as properties of the underlying stellar population. **We find that five out of six interacting galaxy systems show signs of AGN activity with a wide range of properties.** Our data provide the first clues for the efficiency with which the mid-infrared pre-selection technique finds dual AGN, which could exponentially increase the population of dual accretion systems in advanced mergers and thus could revolutionize our understanding of the coeval evolution of supermassive black holes and galaxies.

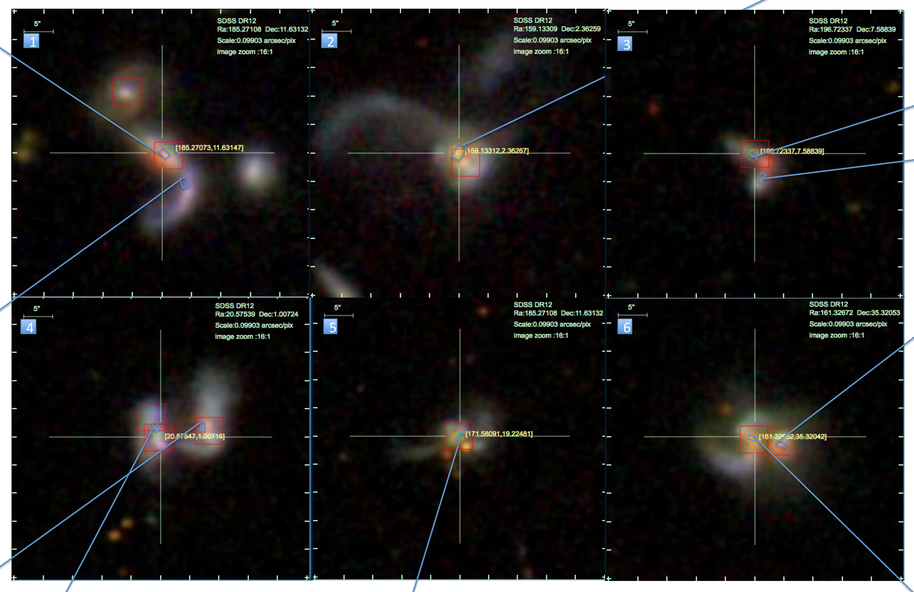


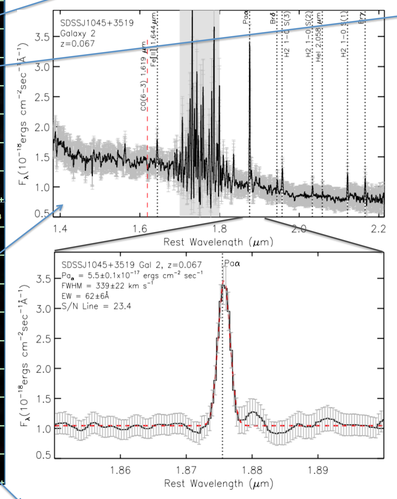

SDSSJ1036+0221: Coalesced object with a rich variety of emission lines. The presence of the [Si X] emission feature is stronly indicative of an AGN. Production of this line requires a spectral energy distribution that can only be provided by accretion onto a SMBH. Its $H_2$/Brγ line flux ratio is consistent with an AGN nature.The 10 pixel extraction corresponds to 2.5 kpc at the redshift of the target.



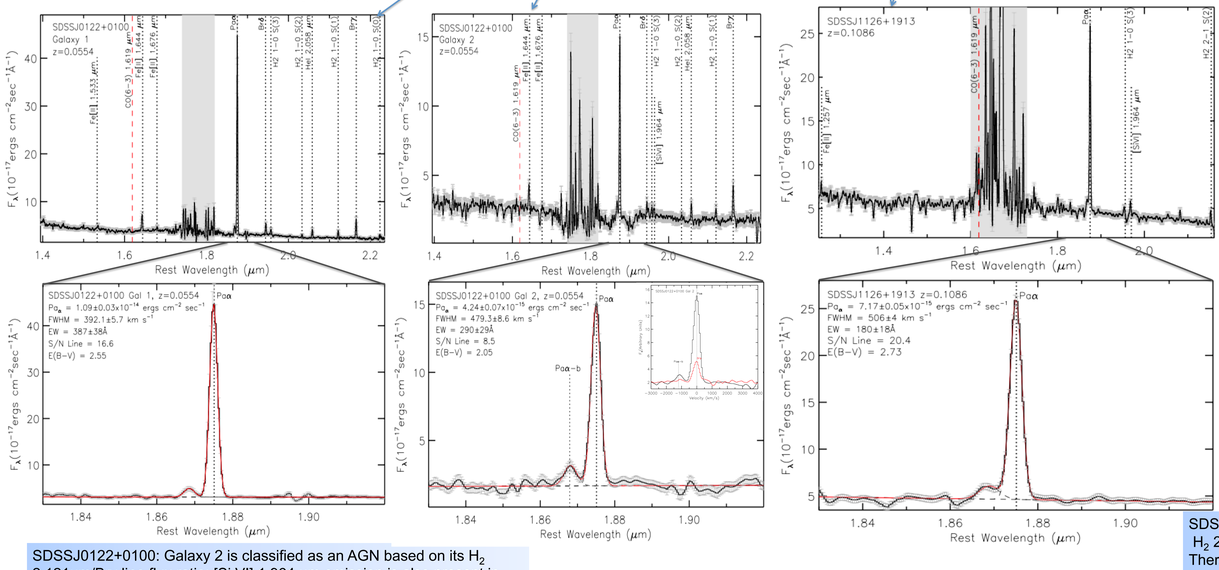

SDSSJ1221+1137: Galaxy 2 is classified as an AGN using the near-IR line-ratio diagnostic diagram. [Si VI] emission is also present in galaxy 2, which lends credibility to an AGN being the dominant excitation mechanism. Both galaxies use a 4 pixel extraction, which corresponds to 1.3 kpc at the target's redshift.



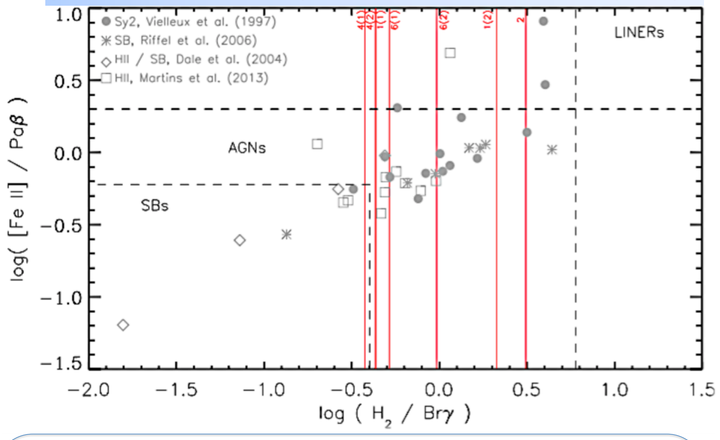




Because infrared emission is less sensitive to dust extinction than optical, it is possible to identify optically elusive AGN by **near-infrared (NIR) diagnostics** instead. In-depth studies of the excitation sources for the strongest NIR spectral features show that the $H_2$/Brγ line flux ratio can efficiently distinguish between Starburst galaxies (SBs), AGNs, and Low Ionization Nuclear Emission Regions (LINERs) because $H_2$ traces the colder molecular gas and is therefore less closely coupled with the high-ionization lines like [O III] used in optical diagnostics (e.g., Larkin 1998, Rodr´iguez-Ardila et al. 2004, 2005). We present here the location of our dual AGNs in the $H_2$ 2.121μm/Brγ × [Fe II] 1.257μm/Paβ diagnostic diagram with the most recent line separation criteria (Riffel et al. 2013). Our data do not cover the Paβ emission, however the $H_2$/Brγ line flux ratio is measured in seven individual galaxies (red lines). **Six of these seven galaxies exhibit $H_2$/Brγ values indicative of AGN activity. The objects with spectra lacking Brγ reveal instead the high-excitation and high-ionization forbidden (coronal) lines implying that the main power source is an AGN** (see comments for the individual spectra).




SDSSJ0122+0100: Galaxy 2 is classified as an AGN based on its $H_2$ 2.121μm/Brγ line flux ratio; [Si VI] 1.964 μm emission is also present in galaxy 2, strongly supporting the AGN interpretation.

SDSSJ1126+1913: Brγ is not covered in our spectrum so the $H_2$ 2.121μm/Brγ × [Fe II] 1.257μm/Paβ diagnostic diagram can't be used; There is however a strong [Si VI] emission found, suggesting the presence of an AGN. The rich absorption line spectrum will allow for strong diagnostics of the age of the stellar population associated with this nucleus. The 3 pixel extraction aperture corresponds to 1.42 kpc of physical space.




**References**: **Dale, D. A.**, Roussel, H., Contursi, A., et al. 2004, *ApJ*, **601**, 813; **Larkin, J. E.**, Armus, L., Knop, R. A., Soifer, B. T., & Matthews, K. 1998, *ApJS*, **114**, 59; **Riffel, R.**, Rodr´iguez-Ardila, A., & Pastoriza, M. G. 2006, *A&A*, **457**, 61; **Riffel, R.**, Rodr´iguez-Ardila, A., Aleman, I., et al. 2013, *MNRAS*, **430**, 2002; **Martins, L. P.**, Rodr´iguez-Ardila, A., Diniz, S., Gruenwald, R., & de Souza, R. 2013, *MNRAS*, **431**, 1823; **Satyapal, S.**, et al. 2014 *ApJ*, **784**, 113; **Smith, K. L.**, et al. 2014 *ApJ*, **794**, 112; **Seifert, W.** et al. 2003, *SPIE*, **4841**,962; **Seifert, W.** et al. 2010, *SPIE*, **7735**, 7; **Veilleux, S.**, Goodrich, R. W., & Hill, G. J. 1997, *ApJ*, **477**, 631

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