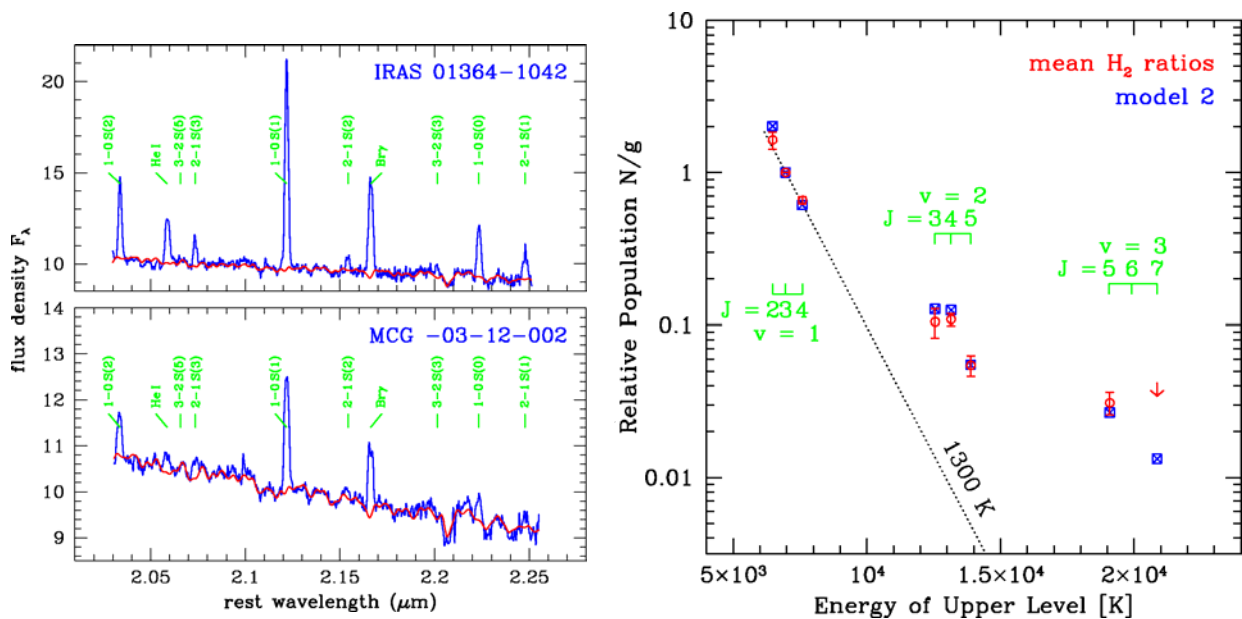


A detailed analysis of the molecular hydrogen and ionised hydrogen/helium line fluxes in a sample of ULIRGs provides a consistent picture of young star clusters surrounded by dense photo-dissociation regions that are irradiated by intense far-ultraviolet radiation.

In ultraluminous galaxies (ULIRGs) the H<sub>2</sub> 1-0 S(1) line is often stronger than Br $\gamma$ , but its excitation mechanism is not known even though it has the potential to distinguish between dynamical excitation in shock waves and radiatively driven processes. Using ISAAC on the VLT, we have found that there is little variation in the K-band H<sub>2</sub> ratios between ULIRGs. In all cases the  $\nu=1-0$  emission appears thermalised at about 1000 K, but the 2-1 and 3-2 transitions show evidence of being radiatively excited by far-ultraviolet (FUV) photons, indicating that the H<sub>2</sub> emission in ULIRGs arises in dense photon-dominated regions (PDRs). The line ratios in the nuclei are consistent with cloud densities between 10<sup>4</sup> and 10<sup>5</sup> cm<sup>-3</sup>, exposed to FUV radiation fields at least 10<sup>3</sup> times more intense than the ambient FUV field in the local interstellar medium. Starburst models for the ULIRGs based on the H<sub>2</sub> properties as well as the intensities of the He I and Br $\gamma$  recombination lines provide a consistent picture of young 1-5 Myr star clusters surrounded by relatively dense PDRs that are irradiated by intense FUV fluxes.



K-band spectra of 2 galaxies in the ULIRG sample, with the positions of the emission lines marked. Overplotted is the stellar continuum, derived in each case from a set of template spectra. This has been fitted and subtracted in order to facilitate measurement of the fluxes of weak lines.

Excitation diagram showing the relative populations of the upper levels of the observed H<sub>2</sub> transitions. The data (red) shown are the mean ratios for all the ULIRGs in the sample, with the error bars indicating the standard deviation between the objects. The model (blue), which provides an excellent match to the data, is that described above.

published as: Davies, Sternberg, Lehnert, Tacconi-Garman, 2004; ApJ, 597, 907