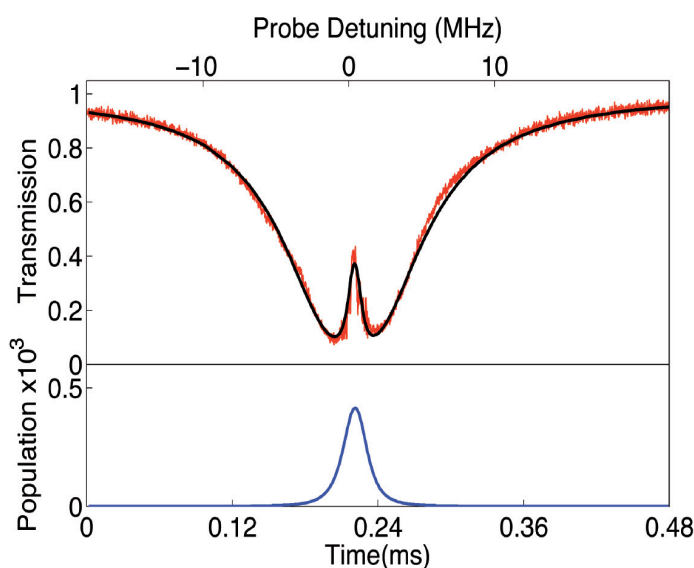


## Electromagnetically induced transparency of a cold Rydberg ensemble

One of the most useful properties of light is that it is very robust, for example, you can send a pulse of light down an optical fibre and it emerges at the other end essentially unchanged. However, this robustness means that when we do want to control the properties of light it can be very difficult, especially at the low intensity levels that are most useful. In this paper we show that if light propagates through a medium where the electrons are very weakly bound (in our experiment a gas of so called Rydberg atoms where one electron is moved far away from the nucleus) then we observe that the light propagation becomes sensitive to the state of neighbouring atoms. In particular, we observe that if neighbouring atoms are excited to the Rydberg state then their interaction induces a transition to other Rydberg states, which changes the transmission through the medium. In future work we plan to exploit this cooperative non-linearity to control light propagation at the lowest possible light levels of single photons. ■

K. J. Weatherill, J. D. Pritchard, R. P. Abel,  
M. G. Bason, A. K. Mohapatra and C. S. Adams,  
'Electromagnetically induced transparency of  
an interacting cold Rydberg ensemble',  
*J. Phys. B: At. Mol. Opt. Phys.* 41, 201002 (2008)



▲ Spectrum showing transmission of a probe laser through a sample of cold Rubidium atoms coupled to the 26d Rydberg state. The scan shows a narrow feature of increased transmission at the centre of the normal absorption line caused by electromagnetically induced transparency (EIT) where the probe and coupling lasers are on the two-photon resonance to the Rydberg state. The linewidth of the EIT feature is 400 kHz, allowing high resolution probing of the Rydberg level.

## Dynamics of the formation of antibubbles

Aptly named, an antibubble is a spherical domain with inverted liquid and gas phases so that a thin shell of air encapsulates the liquid phase and the whole object resides in liquid. The

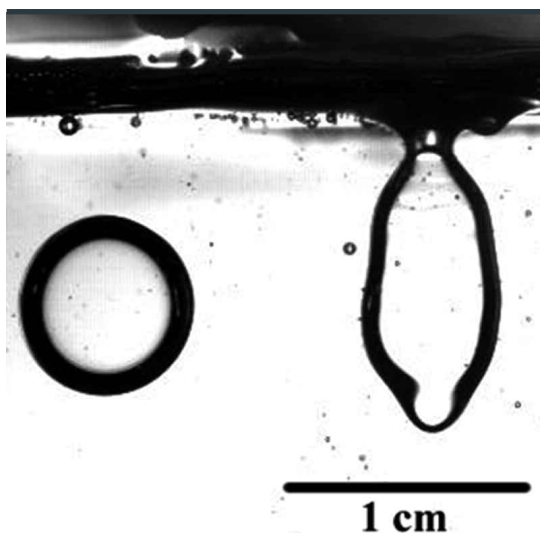
lifetime of these gas-shell-coated liquid drops is typically less than a minute. To produce antibubbles, drops of detergent solution can be dropped into a bath of the solution, but their production is rather fickle because of their delicate nature; it is not simple to form a stable gas shell. The study of the optimal conditions and the dynamics of the formation of antibubbles are important if these objects are to be used in future studies and applications.

Using particle tracking to quantify the number of antibubbles formed in an aqueous soap solution, we identified the optimal conditions for formation (release drops from a height of 8-18 mm with an initial velocity less than 24 cm/s). We also rationalized the existence

of the two boundaries of the fall height using theories for film entrainment processes: If the impact velocity is too low, then the drop cannot penetrate the free surface sufficiently to induce budding off of an antibubble. Also, if the impact velocity is too high, then rapid drainage of the trapped air film between the drop and the solution causes rupture of the film.

The final step in the formation of the antibubble involves the pinching off of an antibubble from the free surface (see Figure). Image analysis of the rate of the pinching reveals that it is significantly dependent on surface tension. Taken together our results for antibubble formation reveal a multi-step, delicate interplay of inertial and surface tension effects, which gives rise to a rare phenomenon. ■

P. G. Kim and H. A. Stone,  
'Dynamics of the formation of  
antibubbles', *EPL* 83, 54001 (2008)



▲ An antibubble pinches off from the surface (right) to produce a complete antibubble (left). The gas film appears black.