

# ZEN and the search for high-redshift galaxies

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## **Abstract**

We present the ZEN ( $z$  equals nine) survey: a deep, narrow  $J$ -band search for protogalactic Ly  $\alpha$  emission at redshifts  $z \sim 9$ . In the first phase of the survey, dubbed ZEN1, we combine an exceptionally deep image of the Hubble Deep Field South, obtained using a narrow-band filter centred on the wavelength  $1.187 \mu\text{m}$ , with existing deep, broad band images covering optical to near infrared wavelengths. Candidate  $z \sim 9$  Ly  $\alpha$ -emitting galaxies display a significant narrow-band excess relative to the  $J_s$ -band that are undetected at optical wavelengths. We detect no sources consistent with this criterion to the 90% point source flux limit of the NB image,  $F_{\text{NB}} = 3.28 \times 10^{-18} \text{ ergs s}^{-1} \text{ cm}^{-2}$ . The survey selection function indicates that we have sampled a volume of approximately  $340 \text{ h}^{-3} \text{ Mpc}^3$  to a Ly  $\alpha$  emission luminosity of  $10^{43} \text{ h}^{-2} \text{ ergs s}^{-1}$ . When compared to the predicted properties of  $z \sim 9$  galaxies based upon no evolution of observed  $z \sim 6$  Ly  $\alpha$ -emitting galaxies, the ‘volume shortfall’ of the current survey, i.e., the volume required to detect this putative population, is a factor of at least 8–10. We also discuss continuing narrow  $J$ -band imaging surveys that will reduce the volume shortfall factor to the point where the no-evolution prediction from  $z \sim 6$  is probed in a meaningful manner.