SDSS1257+5428: an extreme mass-ratio double white dwarf

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We present time-resolved spectroscopy of SDSS J1257+5428, a white dwarf from the Sloan Digital Sky Survey. In 2009 SDSS J1257+5428 was found to be part of a binary with a period of 4.56 hours, and fits to its spectrum combined with its orbital parameters led to the suggestion that it had a high-mass compact companion, either a neutron star or black-hole. Here we show instead that it consists of two DA white dwarfs, one of high mass, around $1\,M_\odot$ and one of low mass $0.2\,M_\odot$. SDSS J1257+5428 is of exceptional interest as it is the first double white dwarf known which has an extreme enough mass-ratio to survive the future onset of mass transfer and become a semi-detached hydrogen-deficient interacting binary (an AM CVn star). We present evidence which shows that the more massive white dwarf is rapidly rotating with $V \sin i > 500\,\mathrm{km\,s^{-1}}$ as the result of the most recent stage of mass transfer from which its low mass helium white dwarf companion emerged. This is contrary to all current models of the formation of double white dwarfs and suggests that these models may not account for all significant pathways to these objects, which may also be the progenitors of Type Ia supernovae.