# Quenching of positronium by laser induced paramagnetic centers in mesoporous silica at cryogenic temperatures

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## Introduction

The use of mesoporous silica films for the production of positronium has become widespread in recent years [1]. In some applications it may be desirable to use such materials in a cryogenic environment, for example in the cold bore of a superconducting magnet for antihydrogen experiments [2]. We have observed a drastic reduction in the positronium formation efficiency of a porous $SiO_2$ sample [1] following UV laser irradiation at 12 K.

Laser irradiation at room temperature allows us to study Ps atoms within the bulk of the sample and does not induce the same Ps quenching effects.

## Ps Production

Slow positrons from a neon moderated positron beam are magnetically guided into a two-stage, Surko-type positron trap [3] which produces 6 ns wide pulses at 1 Hz. The bunched output of the trap is implanted into a porous $SiO_2$ target which is mounted on a cryogenic cold head with a base temperature of 12 K.

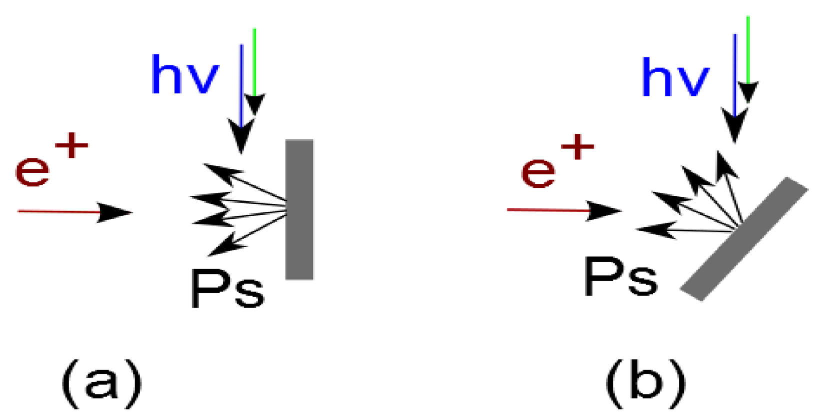


Figure 1: Time-bunched positron pulses incident on a porous silica target. (a) perpendicular arrangement for vacuum positronium studies. (b) Angled arrangement for inner-sample positronium studies.

## Detection of *o*-Ps annihilation

The positron lifetime spectrum is obtained with 'single shot positron annihilation lifetime spectroscopy' (SSPALS) [4]. This technique allows us to distinguish between gamma rays originating from prompt annihilations and those that are delayed, which we attribute to *ortho*-positronium decay.

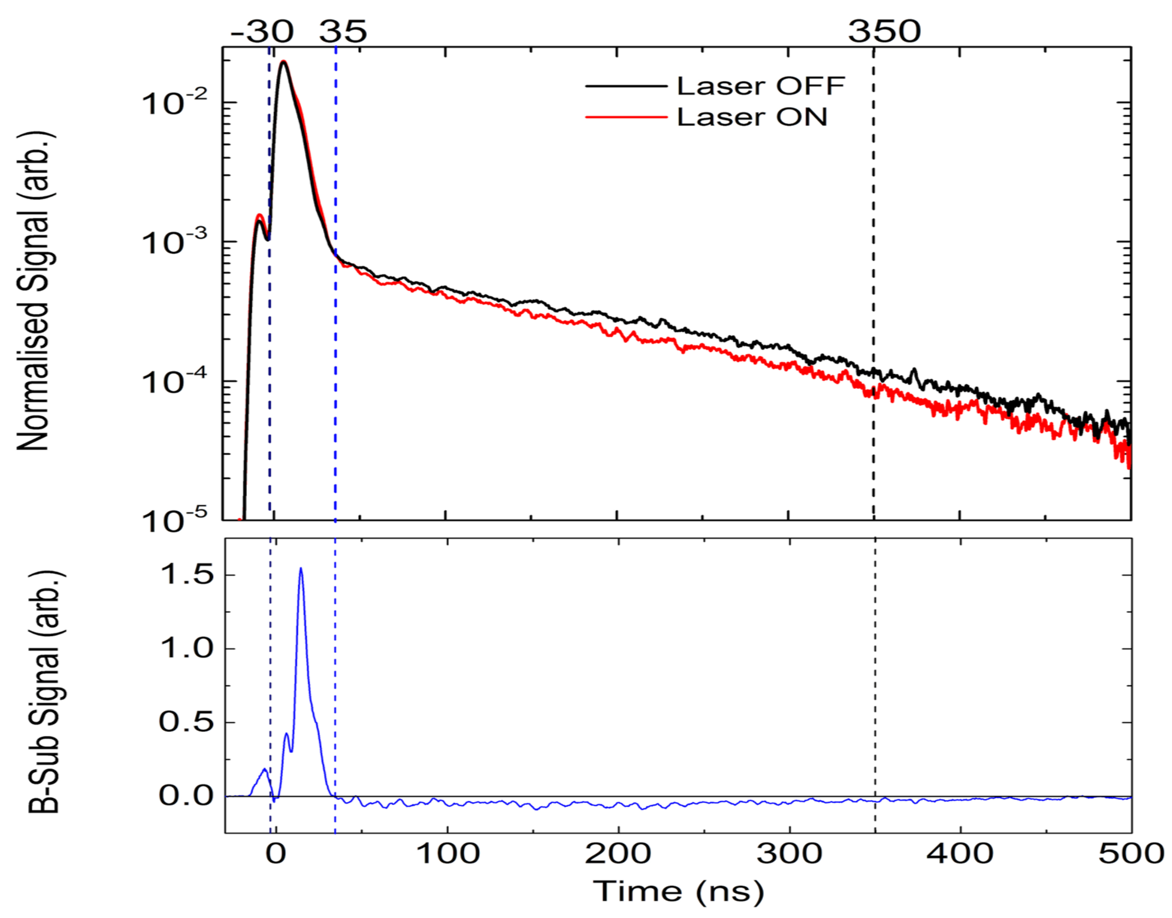


Figure 2: Comparison of the lifetime spectra for positronium atoms with and without excitation and ionising lasers. The prompt annihilation signal is seen between -30 and 35 ns. The delayed annihilation fraction (*fd*) compares the prompt signal with events at later times (35-350 ns). The difference of the two spectra is shown below.

## Cooling silica samples

The postronium conversion efficiency of a porous $SiO_2$ target is reduced if the sample surface is contaminated with residual gas at low temperatures.

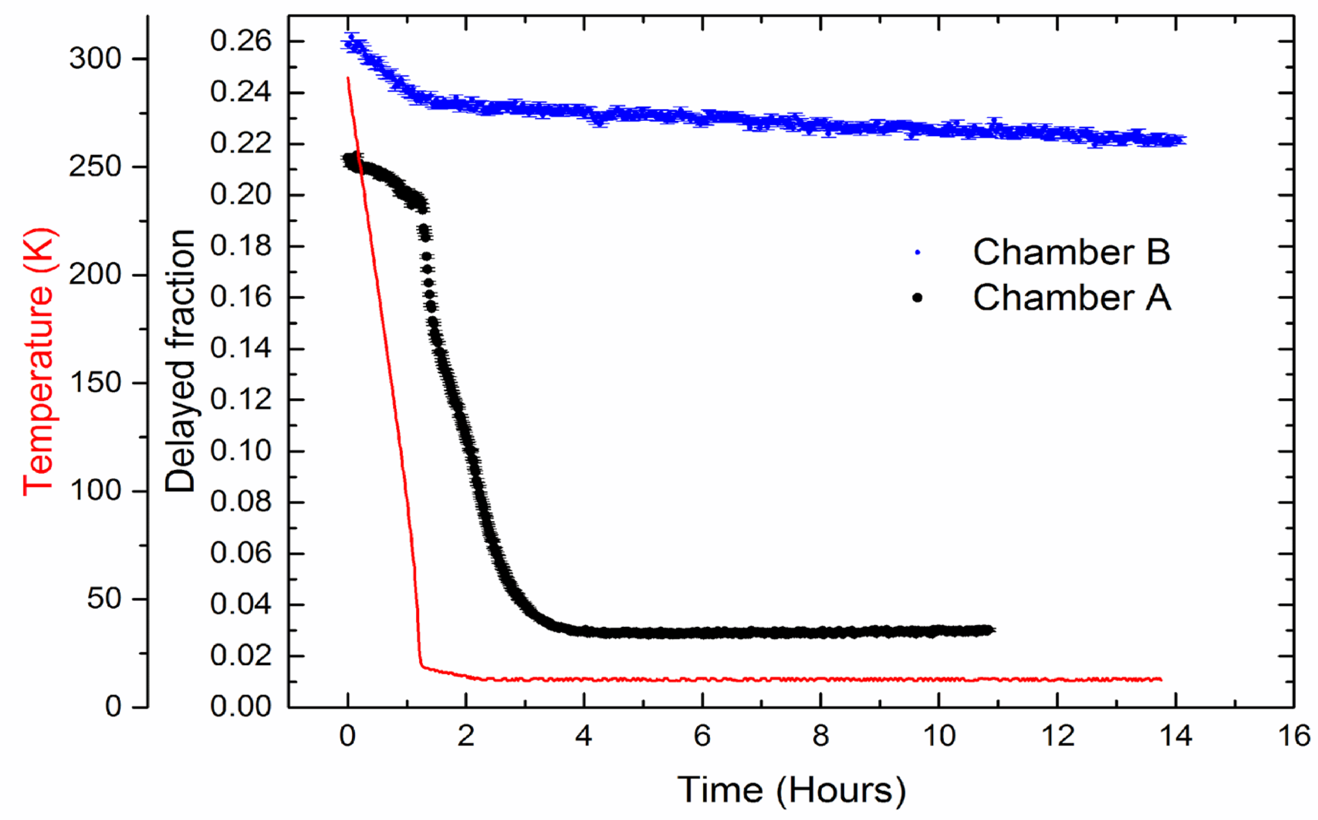


Figure 4: Comparison of the positronium production efficiency of similar samples, in two chambers of differing base pressure as the target is cooled. Chamber A ~ 2 x $10^{-6}$ mbar, and chamber B ~ 3 x $10^{-8}$ mbar. The reduction in pressure was achieved with distance from the buffer gas trap.

## Laser Irradiation of samples at room temperature

We have performed laser spectroscopy of positronium at room temperature for both geometries shown in figure 1. We use 6 ns, 243 nm (UV) pulses (~ 1mJ) to drive the 1s-2p transition in Ps. Atoms in the 2p state are then photo-ionised with 532 nm (visible, green) light (~ 20 mJ).

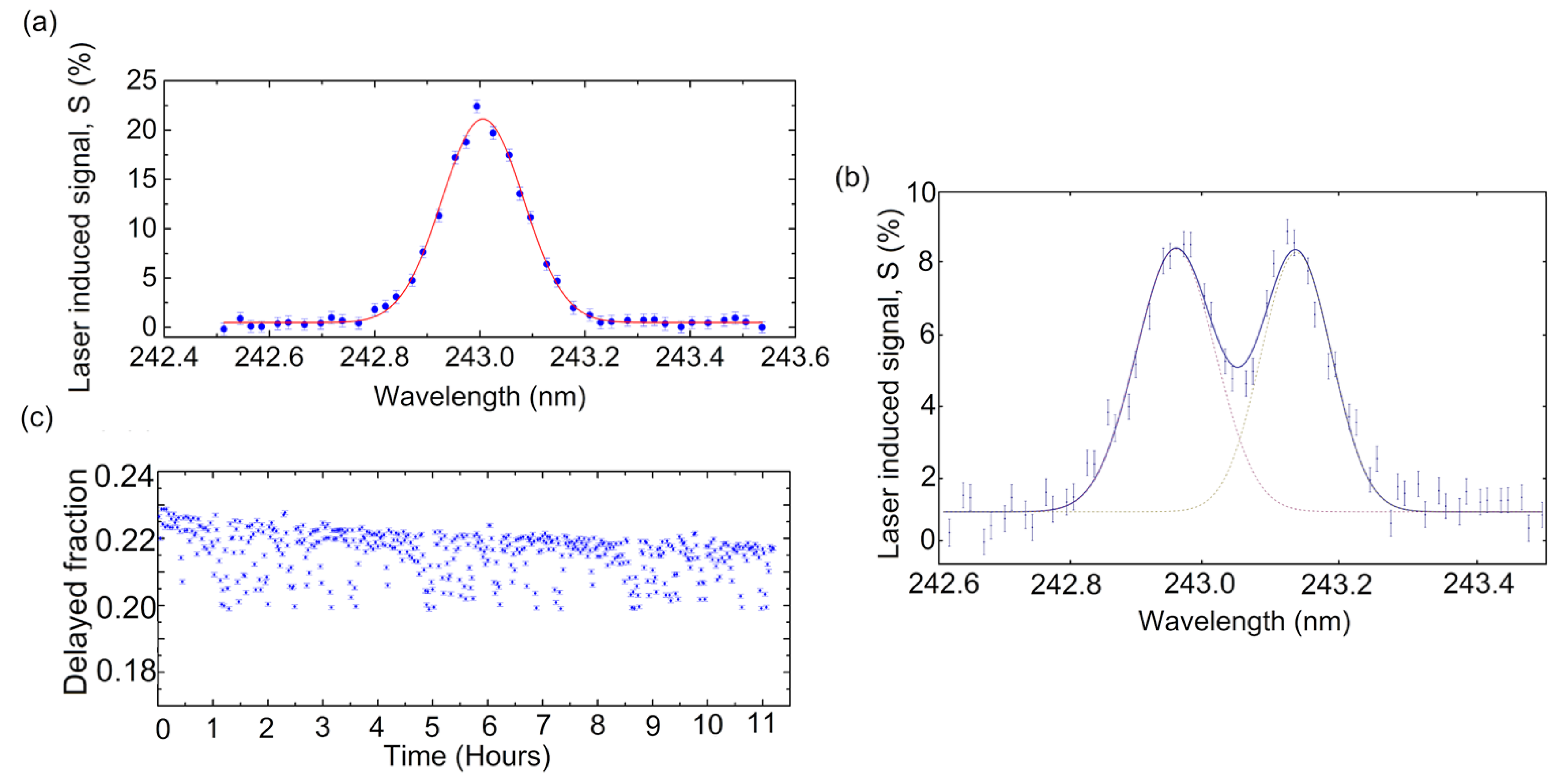


Figure 3: (a) 1s-2p transition of vacuum positronium, these data were obtained using the arrangement in figure 1(a). (b) Cavity shifted 1s-2p transition, the shorter wavelength components represent Ps atoms within the bulk of the target material. (c) Stable Ps conversion over time as the lasers are directed into the sample. (b) and (c) were obtained using the geometry shown in figure 1(b).

## Laser induced paramagnetic centers at 12 K

When the sample is cold and the experiment follows the geometry of figure 1(b), there is a drastic reduction in Ps production efficiency in porous silica samples when the lasers are fired. We predict that at low temperatures, laser irradiation of the target creates long lived paramagnetic centers [4] which can be annealed out with increasing temperature.

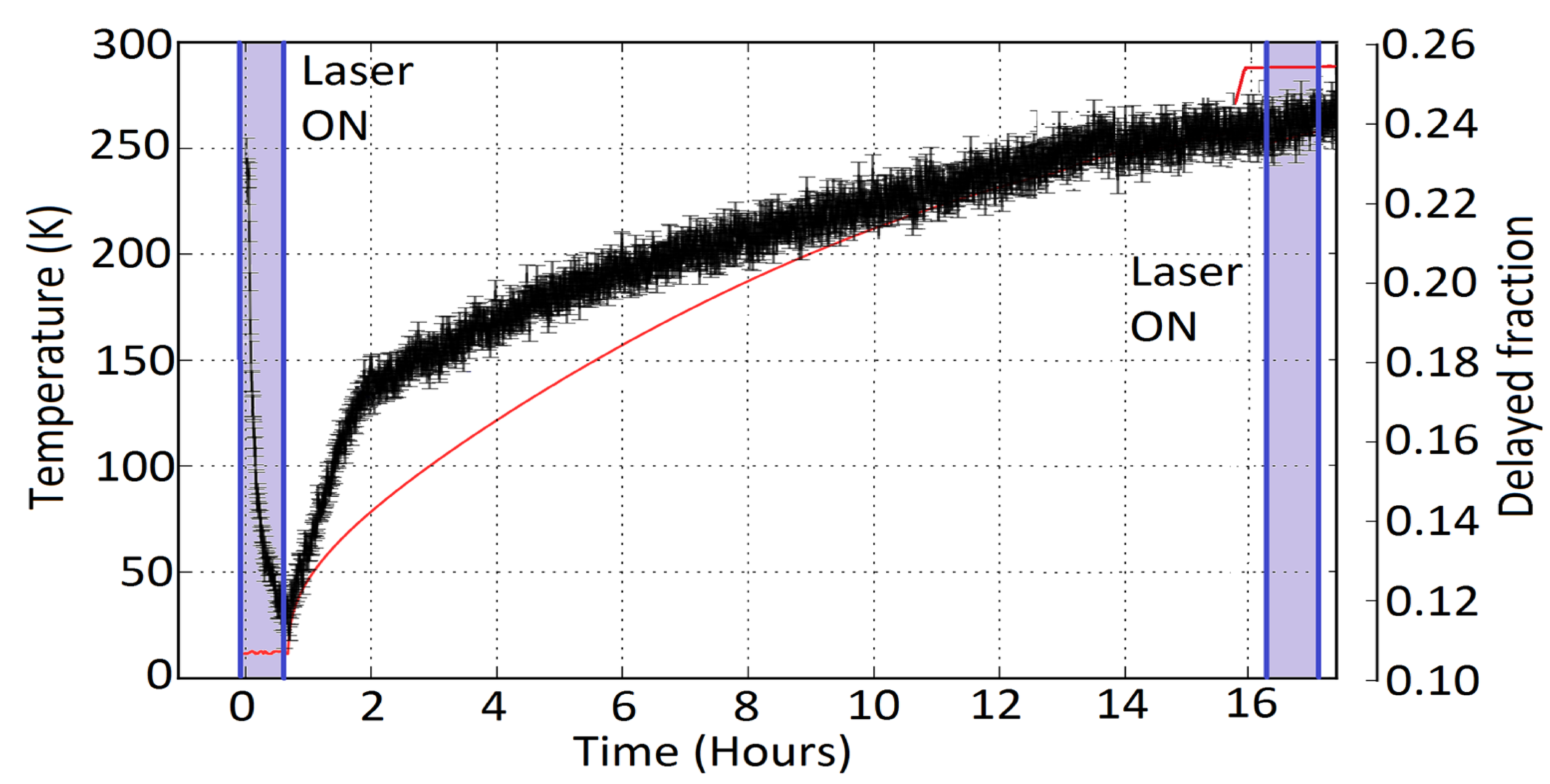


Figure 5: The delayed fraction, which is proportional to the positronium formation efficiency decays following UV laser irradiation at 12 K. A full recovery is observed as the sample is warmed to room temperature where the laser has no detrimental effect.

## Summary

We have observed a drastic reduction in the positronium formation efficiency of a porous $SiO_2$ sample following UV laser irradiation at 12 K. With the sample at room temperature the observed Ps fraction was stable . At 12 K the positronium formation efficiency was slightly reduced due to the adsorption of residual gas by approximately 2% per day. However, following irradiation with UV laser light (243 nm) at 12 K the Ps fraction dropped significantly, as shown in figure 5. No effects from laser irradiation were observed at room temperature and the low temperature laser induced damage was fully annealed out after warming the target to room temperature. These observations are consistent with the formation of paramagnetic centers, as observed by Saito et al [5], who observed quenching of ground state Ps atoms by surface paramagnetic centers in silica aerogels.

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This poster can be downloaded from www.antimattergravity.com

## References

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