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Comment

Have positron-helium scattering resonances been observed?

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Abstract. We comment on the recent claim by Karwasz [Eur. Phys. J. D **35**, 267 (2005)] that he observed resonant structures in the total cross-section for positron scattering from helium. We frame our observations in terms of both the general capabilities of the Trento spectrometer, and new checks we have made on the measurement procedure employed by Karwasz. We conclude that the observed structures are most likely an experimental artefact, rather than being due to the positron-helium interaction.

PACS. 34.85.+x Positron scattering

The current status for the existence of resonances in positron-atom and positron-molecule scattering is well documented in the seminal review of Surko et al. [1]. Here, the most compelling evidence for their existence is provided by recent energy-resolved studies of positron annihilation rates in hydrocarbons containing more than a few carbon atoms [1]. It is thus of great potential significance and interest that a recent paper [2] reported the finding of two resonances in the positron-helium total cross-section, with peaks at about 1.5 eV and 2.1 eV. These data are presented in Figure 14 of Karwasz [2], and in this comment we examine the evidence for whether they are physical or not.

The measurements embodied in Figure 14 of reference [2] were performed in June 2004 by Karwasz and Pliszka, using the Trento positron spectrometer. There was no contribution from other members of the former Electron and Positron Physics Laboratory in the taking of this data. It is fortunate, for the analysis that follows, that both the original data and the operational conditions used to measure that data, are still available in the records of the Laboratory. The Trento positron spectrometer utilises a ^{22}Na source coupled with a 1 μm tungsten film transmission moderator. Tungsten was thought to produce a positron beam of energy width $\sim$0.5 eV [3], however a definitive measurement in March 2005 in fact showed its width was 0.30 ± 0.05 eV [4]. This is in agreement with the value 0.25 eV measured by Amarenda et al. [5] (incorrectly quoted as 0.04 to 0.05 eV in Karwasz's paper) for a similar system. Since nobody has ever demonstrated a better energy resolution for tungsten moderators, we can categorically rule out any possibility that the Trento spectrometer is capable of producing a positron beam with a width narrower than $\sim$0.25 eV (FWHM).

Consider now Figure 14 of Karwasz [2] in more detail. It is apparent that the sharp rise in the total cross-section, at the second structure, takes place over an energy span of the order of 50 meV or less. This necessarily implies that the apparatus energy resolution would also have to be less than 50 meV, which is an order of magnitude smaller than what the Trento apparatus is capable of producing. In addition, the amplitude of the structures in Figure 14 [2] are enormous: the cross-section at the second peak is more than twice the magnitude of that for the direct process. To put this in perspective, the amplitude of the famous Schulz resonance [6] at 19.367 eV in electron-helium scattering (which is considered a strong one), is of the order of 3% when viewed in the total cross-section with an energy resolution of 0.30 eV. Hence, there are further sound grounds for questioning whether or not the "resonances" reported in Karwasz [2] are physical. As a matter of fact, the Detroit group [7], with a positron beam of energy width 0.1 eV and better signal to noise conditions than those used by Karwasz [2], did not detect any structure within the statistical scatter of their data. Please also note that the energy scale published by Karwasz is wrong by 0.4 eV, as it has been established with numerous later determinations. Therefore any attempt to energy correlate the Detroit and Karwasz's results in Figure 14 of [2] is flawed. Finally, we stress that the

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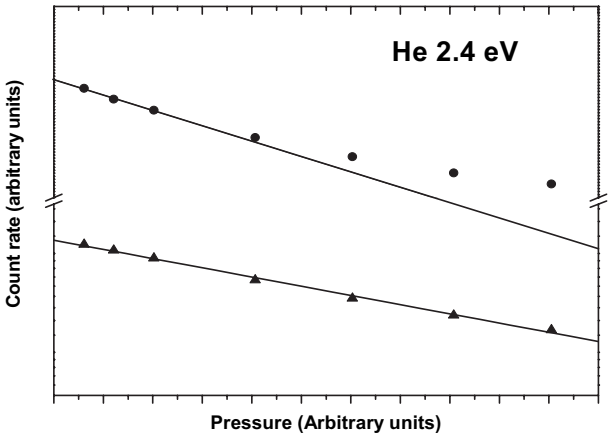

Fig. 1. A plot of the logarithm of the positron count rate versus helium pressure. (•) Uncorrected data of Karwasz [2] and (▲) same data corrected for background. Lines are drawn to evidence non-linearities.

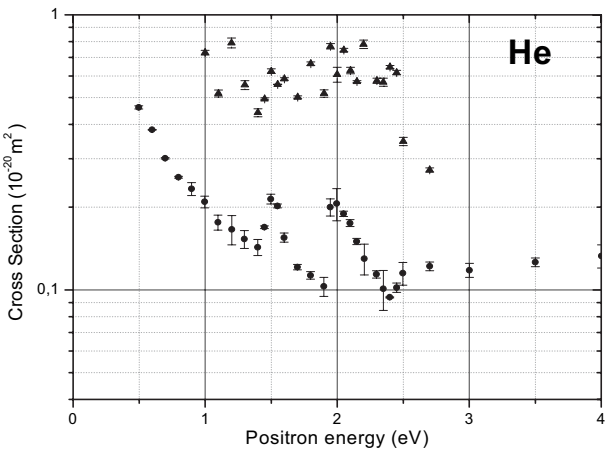

Fig. 2. The He cross-section: (•) as published in [2]; (▲) after the correct background subtraction has been applied.

Trento positron spectrometer was designed and planned for rather large molecules with cross-sections in the range 10 to 100×10^{-20} m^2 [8]. The positron-helium total cross-section is known to be less than about 0.1×10^{-20} m^2 [7,9] in the 1–3 eV energy range, so that applying the Trento spectrometer to the positron-He scattering problem is risky and likely to lead to error.

Given the reservations we have detailed above, we have performed checks on the measurement procedure of Karwasz [2]. We found that in order to achieve a measurable attenuation of the positron beam with the available pumping speed, a very high pressure was needed to be used. With such a high pressure the apparatus pumps were close to overload and the channeltron detector was very nearly in the ion feedback region. Perhaps of more importance than these latter two observations, is that the data measured by Karwasz [2] do not show the well-known linear relationship between the log of the detector count rate and gas pressure (see the dots in our Fig. 1). When we subtract from Karwasz's original data a background count rate, which we can attribute to ion feedback, a linear plot (see the triangles in our Fig. 1) is achieved. Figure 2 shows the helium cross-section as published in [2] compared with the same cross-section obtained with the appropriate background correction (triangles in Fig. 2). The corrected cross-section is higher — as expected. More important, the structures observed by Karwasz disappear into the noise of the measurements. The presence of a background which is of the order of 50% of the total detector counts, amplifies the statistical fluctuations of the signal. In this regime ghost structures can appear in the cross-section, particularly if the background is not properly taken into account.

In conclusion, we have presented arguments as to why the structures reported by Karwasz should be treated with caution. In our view they are in fact an artefact of what is a difficult experiment, rather than being true resonances. The definitive observation of resonance behaviour in positron-helium scattering thus awaits a more sophisticated experiment of significantly better energy resolution.

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