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Evidence of electromagnetic radiation from Ni-H Systems

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We report evidence of photon emission in three experiments with hydrogen loading of Ni slabs, during the degassing phase, when hydrogen was introduced into the cell, and during thermal cycling. In the first experiment we obtained excess power of about 20 W, while in the second experiment photon emission was observed instead of power production. In the third experiment, a Ni sample in hydrogen underwent thermal excitation and showed an increasing photon emission for a few hours.

Introduction

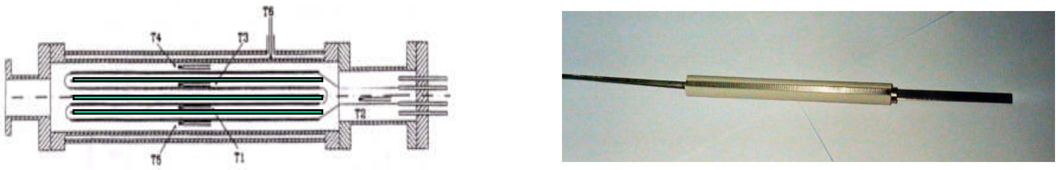
In this paper we present experimental results of photon emission observed during a preliminary preparation step of a Ni-H system. This step is performed to obtain heat production. The emission was detected in three successive experiments in a temperature range between 350 and 750 K.

During previous experiments in which anomalous energy was produced from Ni samples in H atmosphere [1, 2, 3], evidence was obtained of nuclear phenomena occurring in the samples [4] and of ionising radiation coming from the experimental cell [3, 5]. Other authors reported similar evidence with electrolytic systems [6, 7].

The purpose of the experiments described here was to obtain detailed information and confirmation of gamma emission [3] and to perform a calorimetric evaluation of the cell energy balance using samples whose geometry was different from the one considered elsewhere [1, 2, 3].

Experimental setup

Experimental cell. The cell vessel consists of a stainless steel tube (AISI 304) having at the extremities two standard CF35 flanges. In the cell there are three Ni samples (99.5% purity) with slab geometry (200×12×1 mm^3), prepared in a hydrogen environment [2]. The heater consists of four plate coils, each made from a small NiCr slab of analogous dimensions, connected in series and held in a ceramic cylinder with the Ni samples in alternating positions (see Fig. 1).



a) b)

Figure 1. a) The experimental cell for three planar samples alternate with four planar heaters. T_i indicates thermocouples. b) The ceramic holder with a heater inside and a sample on the right.

All measurements (temperature, pressure, power) are performed with the Labview data acquisition system as reported in Refs. 1 and 2. The experimental setup is shown in figure 2.

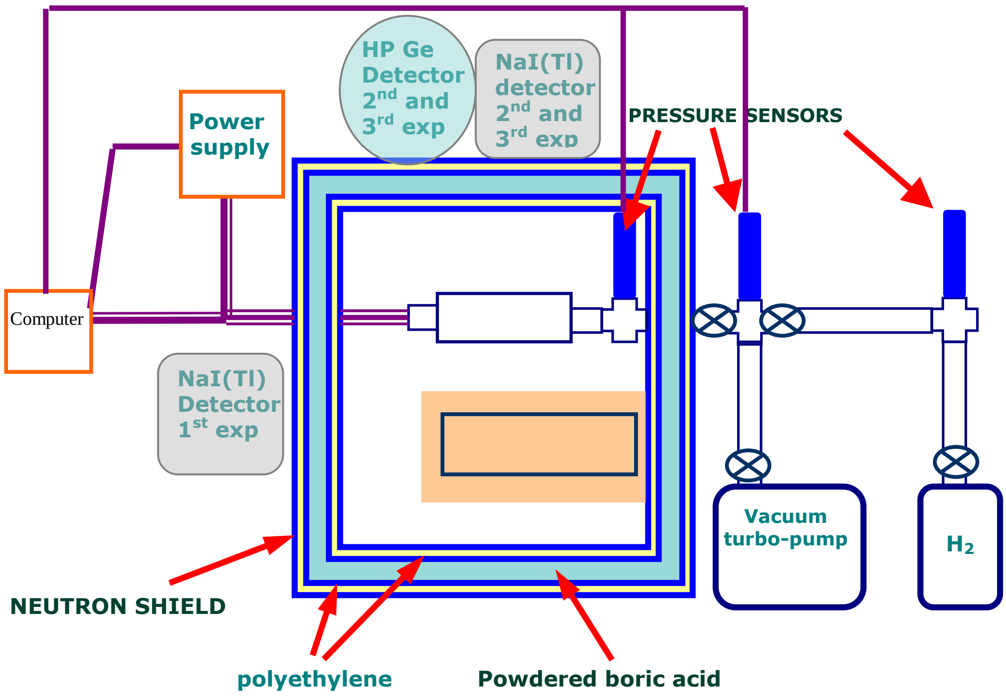


Figure 2 . A schematic layout of the experimental setup.

Neutron shield. In previous experiments we detected neutron emissions [3, 5]. Thus, for safety reasons, the cell was placed within a neutron shield (see Fig. 3). The shield is cube 100 cm on each side with walls 10 cm thick. The walls are made of polyethylene with an interstice of powdered boric acid (width 3.5 cm).

Photon detection. The measurement was obtained with a NaI(Tl) 4×4" detector and acquisition software (EG&G Ortec, Maestro II). Later on, to obtain a more accurate photon energy measurement, we used an HPGe detector having 7% efficiency and Silena EMCA PLUS acquisition software. Figure 2 shows the detector positions in all experiments.

Photon emission

The measurements were performed automatically, each recording having a fixed live time, usually 12000 or 18000 s.

In the first experiment the NaI detector was in front, as shown in figure 2. During a degassing phase [2] five days after the start, when the sample temperature was about 420 K, the NaI detector was turned on. The γ spectrum showed a structure different from the background. Figure 3 shows the measured γ spectrum, the background spectrum, and the spectrum given by the difference between the two. In the difference spectrum the presence of three peaks superimposed on a continuous low energy spectrum can be observed.

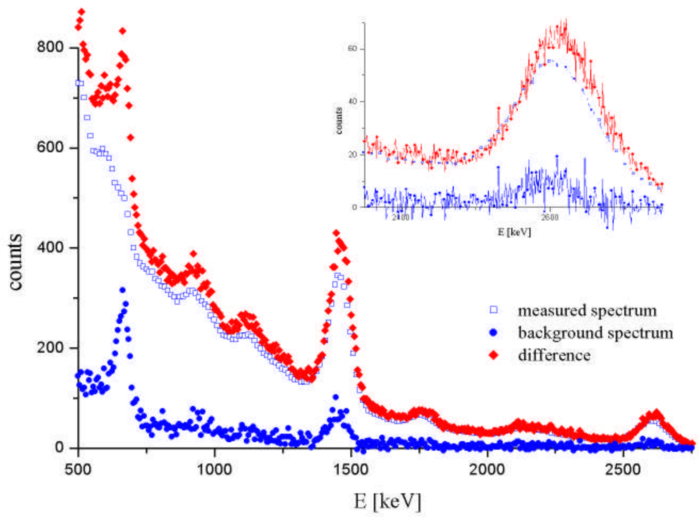


Figure 3. First experiment: background and measured spectra, at the beginning of gamma measurements, obtained with the NaI(Tl) detector placed in front. The background spectrum is a mean of 90 acquisition (live time 12000 s) while the measured one is a mean of 6 acquisitions. The lower curve is the difference between measured and background spectrum.

Five days later we observed a sudden variation in photon spectrum with a lowering of the intensity of the three peaks as shown in Fig. 4.

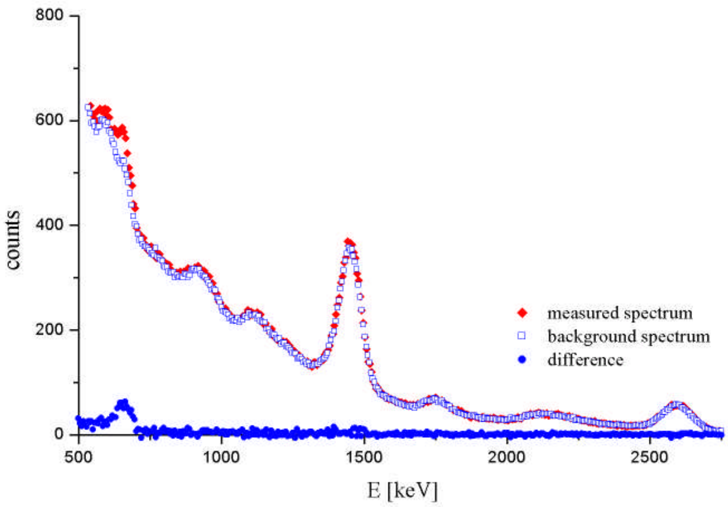


Figure 4. First experiment: background and measured spectra 45 days after the beginning of gamma measurements, the measured spectrum is a mean of 18 acquisitions. The lower curve is the difference between measured and background spectra.

Peak intensity did not show detectable variation with gas admission, which was performed 19 days after the start of degassing. This emission lasted on the whole about 45 days. After this time period the spectrum went abruptly to the background one. Later on the cell produced excess power (maximum 25 W measured with the method reported in Ref. 2) for about 35 days, after which the cell was shut down, in order to repeat the experiment.

In the second experiment new samples were used and the HPGe was added to attempt a quantitative measurement of photon energy [8]. In this experiment the HPGe detector was in a lateral position while the NaI detector was placed as shown in Fig. 2. During the degassing period, the very first acquisition revealed a spectrum (Fig. 5) dramatically different from the background one. During some acquisition sequences sample temperature was changed in the range from 350 to 750K without any detectable variation in the γ spectrum. Samples were kept 52 days under vacuum before hydrogen admission in order to study extensively the photon emission. After this too prolonged treatment, the system did not produce energy. It may be that the two phenomena, extended photon emission and energy production, are alternative, and mutually exclusive.

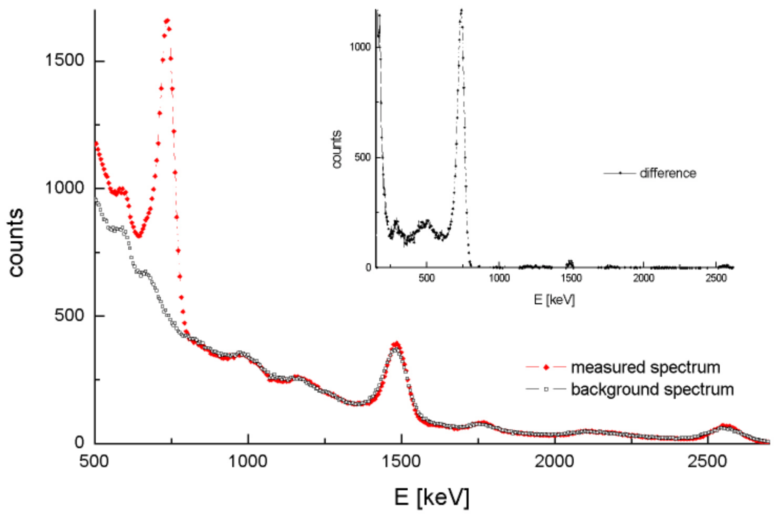


Figure 5. Second experiment: background and measured spectra, at the beginning of gamma measurements. The background spectrum is a mean of 20 acquisitions (live time 18000 s) and the measured one is a mean of 30 acquisitions. The curve in the small picture is the difference between measured and background spectrum..

The behaviour over time of these spectra was similar to the one observed in the first experiment; 26 days after the hydrogen introduction the γ spectrum returned to the background level. During this time period the spectra acquired with the HPGe detector only allowed the determination of the energy of the most intense peak due to the low efficiency of the detector and to the bad geometry imposed by the presence of the neutron shield.

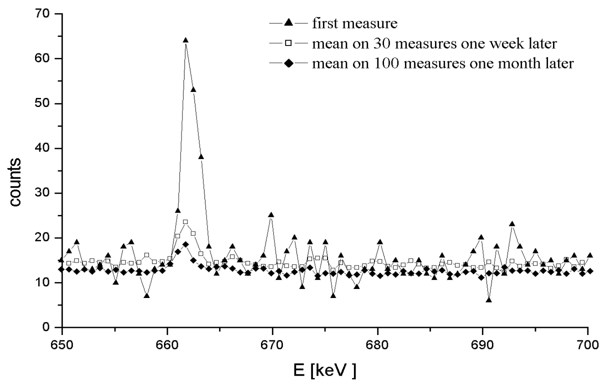


Figure 6. Second experiment: three measured spectra obtained with the HPGe detector. The first spectrum is a single acquisition (live time 12000 s), taken at the beginning of gamma measurements.

Figure 6 shows one of the acquired spectra, relative to the energy range of interest. The detector was calibrated by using natural background peaks, and the energy measurement of the observed peak is 661.5 ± 0.8 keV.

It can be observed in the insert of Fig. 5 that the Compton shoulder is in the expected position (487 keV) and the energy of the left peak corresponds to the back-scattered one (184 keV). The experimental results show in an unambiguous way the existence of processes involving photon emission, obtained in experimental conditions for which such processes are unexpected and unexplainable within the frame of present physical theories. In fact the observed NaI and HPGe spectra are different from those produced by neutrons impinging on the detectors [9, 10].

We maintain that the phenomenon is imputable to Ni (and not to the cell walls and to the heater) because it is not observed without a suitable Ni sample.

An accurate determination of energy was obtained only for the lower energy peak. For this reason, a search on two database (Lawrence Berkeley National Laboratory - GAMQUEST program and Brookhaven National Laboratory - National Nuclear Data Center - NUDAT program) has been performed in the energy range 660.0 - 663.0 keV in order to find a possible nucleus responsible for the emission. In this region we have found only heavy radioactive nuclei (from ^{67}Ge to ^{243}Am) whose presence is difficult to justify. The only exception is ^{50}Mn whose strongest lines are at 1098.0 and 783.3 keV, which were not observed.

Moreover, a possible nuclear excitation of a Ni isotope has been considered. A unique coincidence was found: ^{59}Ni from an highly excited emitting level (level energy 7164 keV and Jpi = 19/2, 21/2-) which is very hard to justify, because the cascade gamma emission to the ground level was not observed.

Finally, in a third experiment with new Ni samples there was no difference in radiation emission during the degassing period and the H atmosphere, as shown in Fig. 7, almost all the time.

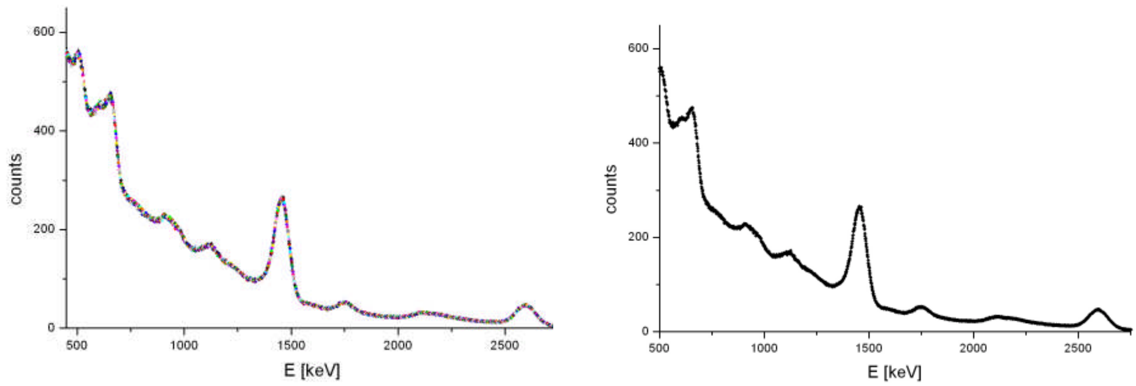


Figure 7. Third experiment: a) a spectrum during the degassing, b) a spectrum in the Hydrogen atmosphere

After the admission of hydrogen, differences in photon emission are revealed only in two very different cases.

The first alteration in radiation emission happened in a condition of closed cell (matter cannot be exchanged with the outside). In this condition, a small thermal excitation was made (the electrical power was turned off for a few minutes) causing a photon emission that persisted for less than 10 hours. The spectra during this period, in the region of energy of interest, are shown in Fig. 8.

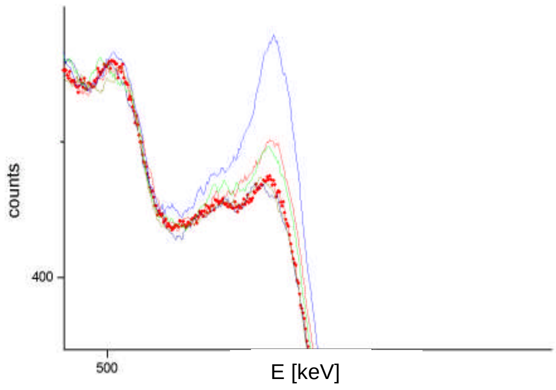


Figure 8. Third experiment: five spectra zoomed in the region of the increasing of emission.

Figure 9 shows the differences between these spectra and the previous one.

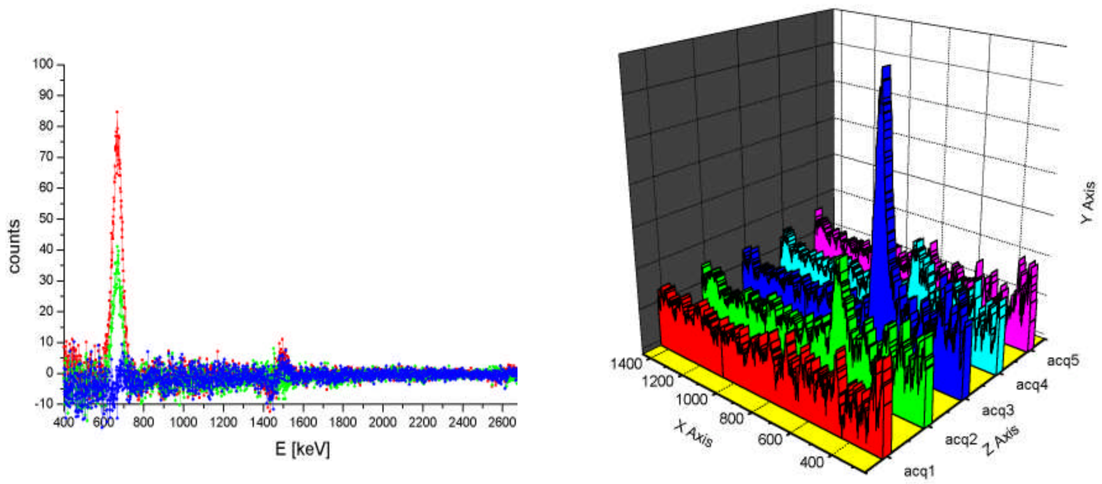


Figure 9. Third experiment: a) Differences between spectra during the excitation and far from it, b) Temporal evolution is shown.

Some weeks later, spontaneous excitation occurred and it persisted unaltered during admission of hydrogen. Again the photon emission increased, this time for a long period of about three weeks.

The spectra of this excitation are shown in Fig. 10 and 11.

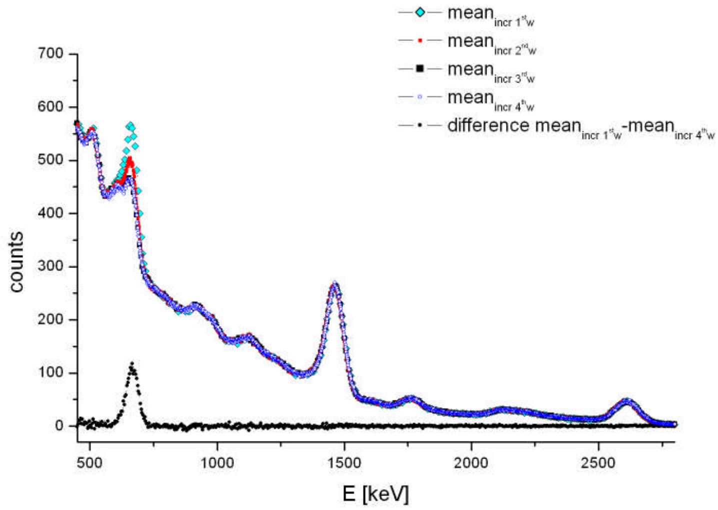


Figure 10. Third experiment: spectra are acquisitions of 12000 s during the excitation and after, a mean over a week is performed.

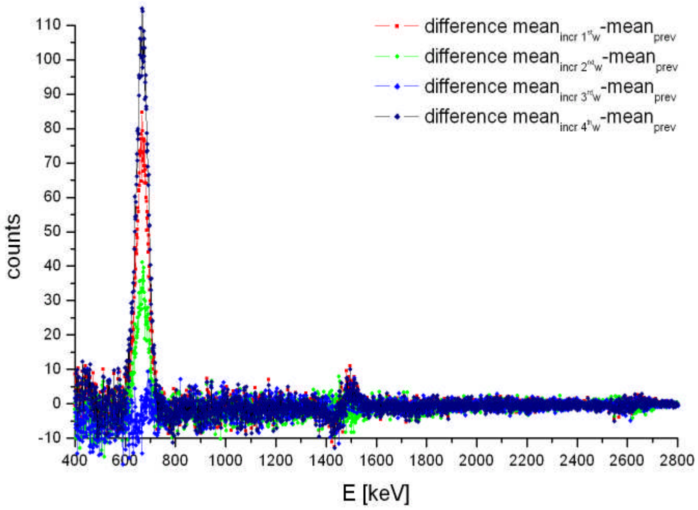


Figure 11. Third experiment: differences between spectra shown in Fig. 10 and a previous weekly mean.

In all these experiments, despite the very different ways and times of emission, the main emitted photon shows a peak at the same energy.

Discussion and conclusion

We have presented experimental results for photon emission observed in three different experiments performed during a preliminary preparation step of a Ni-H heat production system. In this section we briefly reconsider the main phenomena detected in all these experiments.

First experiment A fast loading of hydrogen was observed (a typical loading is shown in Fig. 12) which involved large gas quantities. Radiation was emitted in an early time with peaks that showed low intensities for few days and extremely low intensity for 40 days. It disappeared before the beginning of energy production. No neutron emission was detected during this experiment.

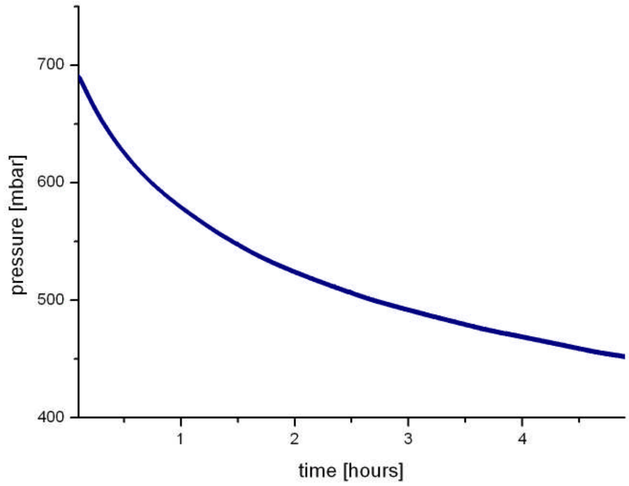


Figure 12. First experiment: a fast loading, large decrease of pressure with characteristic time of 1.8 hours.

Moreover, excess heat was observed [11-13] that persisted for 22 days with a energy production of about 35 MJ. After the experiment, nickel samples were analysed with a Scanning Electron Microscope (SEM) to investigate morphological and elemental difference from a blank sample. The measurements were performed by using an energy dispersive X-ray system for elemental analysis. The most interesting result is shown in Fig. 13: new elements (Cr and Mn) were detected in a wide region of a sample.

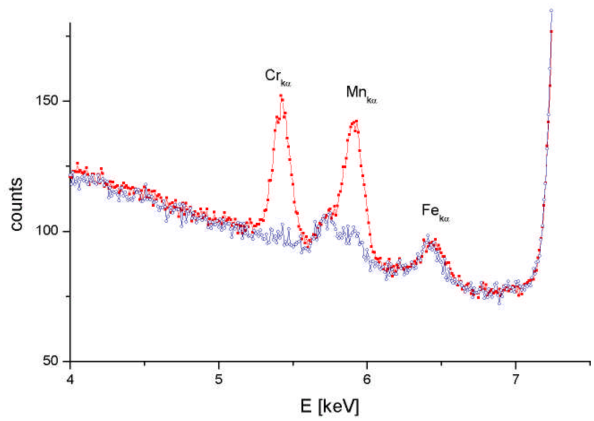


Figure 13. First experiment: surface analysis of a nickel sample performed by using SEM X microprobe (electron gun at 20 kV) on 200 × 200 μm^2 windows. Empty circles indicate an analysis of an unaltered surface on the nickel sample, which is indistinguishable from analysis on a blank sample. Full squares indicate an analysis on a wide altered region. The large peak on the right comes from nickel.

Second experiment A slow loading of hydrogen was observed (a typical loading is shown in Fig. 14) which involved small gas quantities. Radiation was emitted early in the run with peaks that showed high intensities for many days, they decreased slowly and persisted for 78 days (26 in H atmosphere). No neutron emission or excess heat production were detected during this experiment. No quantitative changes were detected in surface analysis.

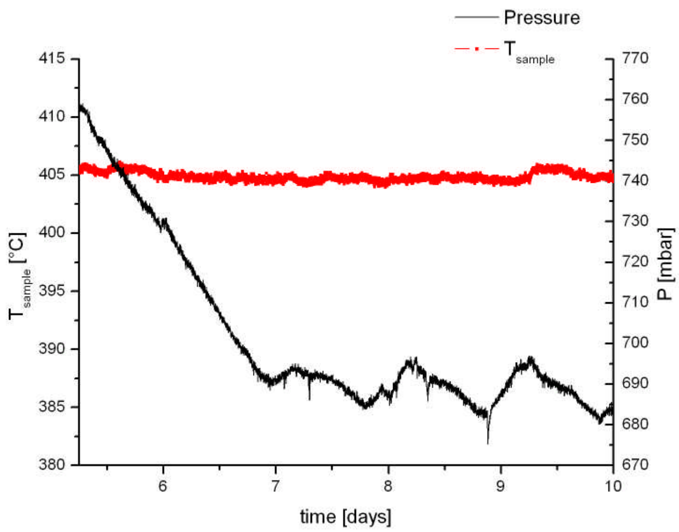


Figure 14. Second experiment: a slow loading, small decrease of pressure with characteristic time of days.

Third experiment A very slow loading of hydrogen was observed which involved very small gas quantities (few tens of mbar, characteristic time of weeks). Radiation was always present with peaks that showed low intensities. A thermal excitation provoked a transient increasing in radiation emitted. A spontaneous increasing persisted for weeks. No neutron emission or excess heat production was detected during this experiment.

In our opinion, these experiments show the complexity of phenomena involved in the physics of the Ni – H system. Further investigations are needed in order to throw light on these phenomena.

Acknowledgments

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