H_2O_2 synthesis induced by irradiation of H_2O with energetic H^+ and Ar^+ ions at various temperatures. R. A. Baragiola,[1] M. J. Loeffler,[1] U. Raut,[1] R. A. Vidal,[1] and R. W. Carlson.[2] [1]University of Virginia, Laboratory for Atomic and Surface Physics, Charlottesville, VA 22904, USA, [2]Jet Propulsion Laboratory, California Institute of Technology, Pasadena, California, 91109.

Introduction: The detection of H_2O_2 on Jupiter's icy satellite Europa by the Galileo NIMS instrument [1] presented a strong evidence for the importance of radiation effects on icy surfaces. A few experiments have investigated whether solar flux of protons incident on Europa ice could cause a significant if any H_2O_2 production [2,3]. These published results differ as to whether H_2O_2 can be formed by ions impacting water at temperatures near 80 K, which are appropriate to Europa. This discrepancy may be a result of the use of different incident ion energies [3], different vacuum conditions, or different ways of processing the data. The latter possibility comes about from the difficulty of identifying the 3.5μm peroxide OH band on the long wavelength wing of the much stronger water 3.1μm band. The problem is aggravated by using straight line baselines to represent the water OH band with a curvature, in the region of the peroxide band, that increases with temperature. To overcome this problem, we use polynomial baselines (figure 1) that provide good fits to the water band and its derivative.

In our experiments we use ice films thicker than the range of the bombarding ions (100 keV protons, and 50 and 100 keV Ar^+ ions). We found that H_2O_2 is produced even at 120 K using 100 keV protons. We also found that, after irradiation, the H_2O_2 band qualitatively appears to decrease as we raise the temperature (e.g. 40 K to 135 K, figure 2). However, when we fit the baseline we find that the calculated band area (and resulting H_2O_2 column density) remains constant until the film begins to desorb from the gold substrate (figure 3).

Using Ar^+ ions we found, as Gomis et al [3], that heavy ions produce substantially more peroxide than protons, at the same energy and ice temperature (figure 4).. We attribute this to the well known enhancement of radiation molecular products in ice when the density of deposited energy is high. This also explains why the experiments of Moore et al [2], using weakly ionizing 800 keV protons on films smaller than the range of the ions, produced much smaller peroxide concentrations. These results can be used to predict that the population of similarly weakly ionizing high energy electrons at the icy satellites will be relatively inefficient to synthesize H_2O_2 in ice.

To study the stability of H_2O_2 we raised the temperature of an irradiated water ice film to 165 K and maintaining this temperature, measured the ratio of H_2O_2 to H_2O band areas as a function of time (figure 5). From figure 5, one can see that the relative amount of H_2O_2 increases with time, which shows that it is not uniformly dispersed in the water ice. Thus, it indicates that the H_2O_2 molecules might be segregated together in pockets of the water ice.

References:

[1] Carlson, R. W. et al. (1999) *Science* 274, 385-88. [2] Moore, M. H. and Hudson R.L. (2000) *Icarus*, 145, 282-288. [3] Gomis, O. et al. (2002) *Planet. Sp. Sci.* (in press)

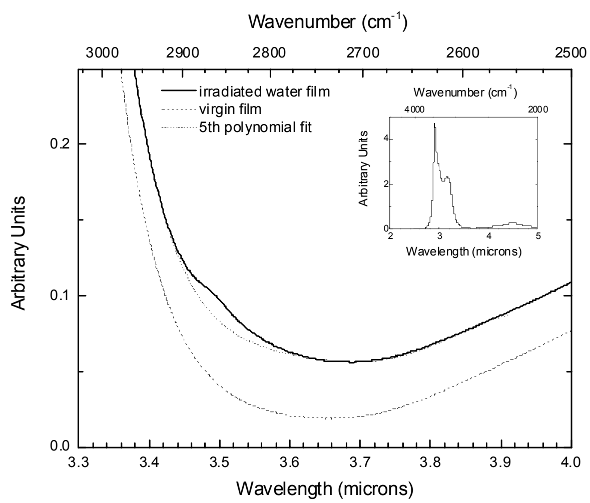

Figure 1. An example of the curve fit used when calculating a baseline for the H_2O_2 region. In this case, a $6x10^{18}$ H_2O/cm^2 water film at 80 K was irradiated with 100 keV protons to a dose of 2.7 x 10^{15} H^+/cm^2.

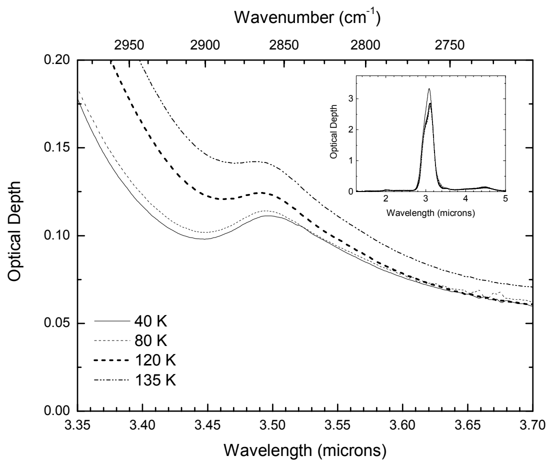

Figure 2. The shape of the H_2O_2 band in a Ar^+ irradiated, $3.2x10^{18}$ H_2O/cm^2, film given with temperature as a parameter..

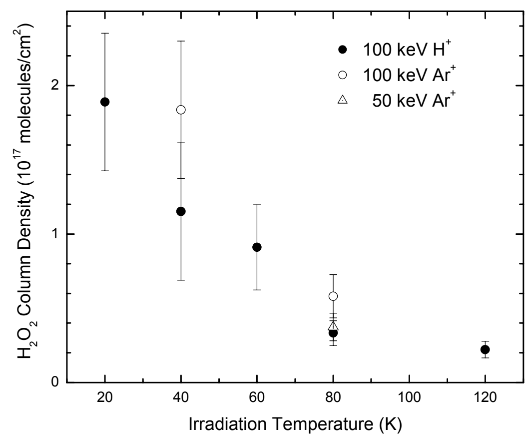

Figure 4. The H_2O_2 column density at saturation values of the irradiation dose for 100 keV H^+ ions incident on $6x10^{18}$ H_2O/cm^2 films at various temperatures, 100 keV Ar^+ ions incident on $3.2x10^{18}$ H_2O/cm^2 film at 40 and 80 K, and 50 keV Ar^+ incident on a 1 μm H_2O film at 80 K.

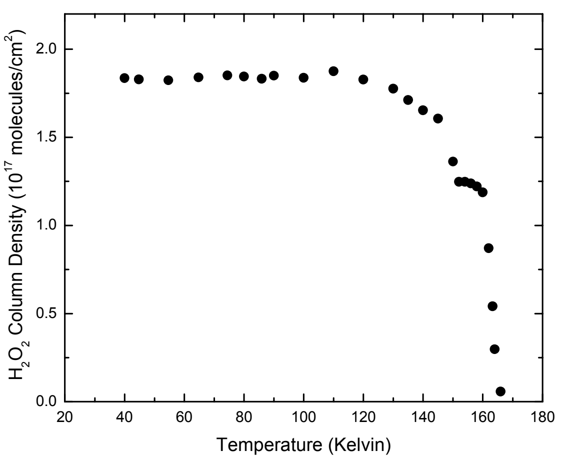

Figure 3. H_2O_2 column density vs temperature. The hydrogen peroxide was synthesized at 40 K by 100 keV Ar^+ ions incident on a $3.2x10^{18}$ H_2O/cm^2 film for which a saturation column density was reached. The temperature of the processed film was raised after the irradiation was stopped.

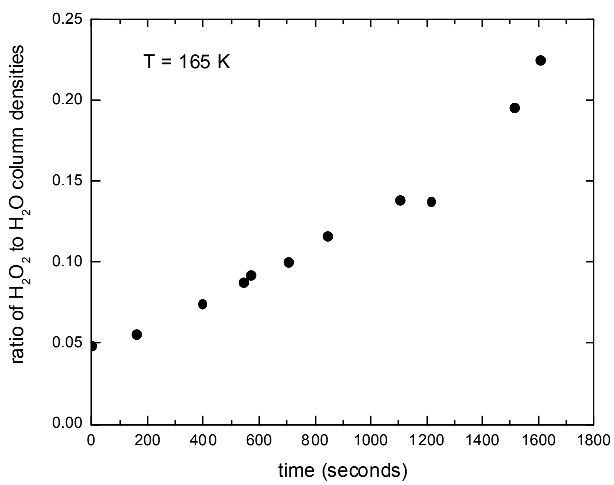

Figure 5. The abundance of H_2O_2 relative to H_2O as the irradiated film sublimes at 165 K. Before raising the temperature to 165 K, the $6x10^{18}$ H_2O/cm^2 film had been irradiated at 20 K with 8.0 x 10^{15} keV H^+ ions/cm^2 at 100 keV.