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Burn Front Data from the Cyclops I Experiment (U)

Guillermo Terrones, Michael W. Burkett, and Christopher Morris

Abstract

This document contains the Cartesian coordinates of the leading edges of the burn waves around the HE in the Cyclops I experiment that were extracted from the proton radiographs taken every microsecond. The reference frame is defined and corresponds to that in the pRad images.

Burn Front Data from the Cyclops I Experiment (U)

The Cyclops assembly consisted of a 10-cm long charge of PBX-9502 confined between an outer cylindrical steel liner and an inner elliptical tin liner. A silicon gel 300 μm thick was used as bonding to hold the charge between the metal liners both of which were 3 mm thick. The charge was initiated with a PBX-9501 booster and a line wave generator (LWG) at 30° from the major axis of the ellipse (the LWG was located 2 mm below the x axis). The proton beam was tailored to detect density changes in the IHE located in the outer region of the field of view. Figure 1a shows a photograph of the assembly before the shot. A cross-section of the HE region, booster block of PBX-9501, and the digitized burn front leading edge coordinates are shown in Fig. 1b. This data set contains only the Cartesian coordinates of the leading edges of the burn waves around the HE referred to the coordinate system depicted in Fig. 1b. We refer to the upper region (U) as that specified by $0 \le \theta \le \pi$ and the lower region (L) by $-\pi \le \theta \le 0$.

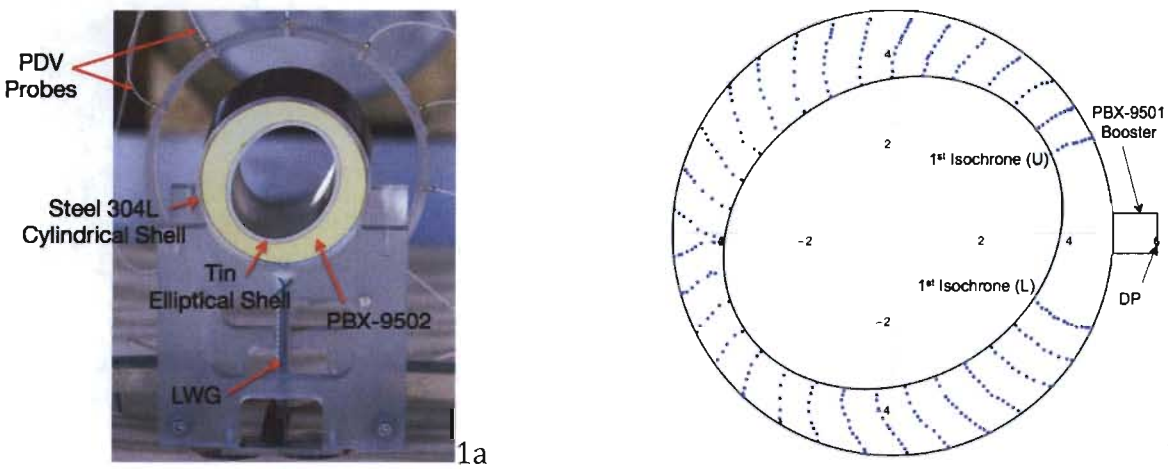

Figure 1. a) Cyclops assembly showing metal liners, IHE, booster, and location of the LWG, b) digitized burn fronts from proton radiographs.

In polar coordinates, the entire IHE region in Fig. 1b can be described by the function $r_{HE} = h(\theta,s)$ given by

$$h(\theta,s) = \frac{(a+s)(b+cs)}{\sqrt{(a+s)^2\sin^2(\theta-30)+(b+cs)^2\cos^2(\theta-30)}}$$

where a=4, b=3.3359, c=1.6641, $h(\theta,0)$ represents the inclined ellipse by 30°, and $h(\theta,1)$ the circle of 5 cm radius. With this parametrization, the extent of the domain of each isochrone function in the s-θ plane is $0 \le s \le 1$ (regardless of its orientation in the r-θ plane). To compare with simulations, t = 0 corresponds to booster initiation. However, the time at which this occurred was not directly measured experimentally. The time interval between booster initiation and the first pRad isochrone was inferred to be about 3.85 μs. Based solely on the variability of each of the points from the digitized isochrone

coordinates, an error estimate in terms of time translates to 3 shakes (this estimate does not capture other sources of experimental error).

The attached text files (titles are self-explanatory) contain the Cartesian coordinates of each individual burn front in the upper (U) and lower regions (L). In all cases the first column corresponds to the abscissa and the second to the ordinate. All of these points are transcribed in Table 1. Also attached is a movie of the pRad experiment beyond the time of total HE burn that consists of 20 images taken every 1 μs (see Fig. 2).

Table 1. Cartesian coordinates of each individual burn front

1st Isochrone (U)	
x	y
3.5800	1.7800
3.7400	1.8500
3.8400	1.9300
3.9300	1.9800
4.0800	2.0100
4.1600	2.0300
4.2700	2.0500
4.3500	2.0900
4.4400	2.1200
4.5000	2.1300

1st Isochrone (L)	
x	y
3.2900	-1.5600
3.3800	-1.6700
3.4900	-1.7200
3.5700	-1.8000
3.6500	-1.8800
3.7500	-1.9200
3.8800	-1.9700
3.9700	-2.0300
4.0500	-2.0600
4.1600	-2.1100
4.2800	-2.1200
4.3800	-2.1300
4.4400	-2.1300

2nd Isochrone (U)	
x	y
3.3000	2.3800
3.4000	2.4300
3.5000	2.5200
3.5900	2.5900
3.6900	2.6400
3.7900	2.7000
3.8900	2.7300
3.9700	2.7700
4.0200	2.7800
4.0500	2.8000
4.0600	2.8100

2nd Isochrone (L)	
x	y
2.8000	-2.0900
2.8800	-2.1900
3.0100	-2.3100
3.1400	-2.3800
3.2900	-2.5200
3.4200	-2.6400
3.5800	-2.7000
3.7700	-2.7900
3.9500	-2.8400
4.0600	-2.8700

3rd Isochrone (U)	
x	y
2.8000	2.9200
2.9400	3.0600
3.0800	3.1800
3.2200	3.2800
3.3700	3.3500
3.4900	3.3700
3.5900	3.4000

3rd Isochrone (L)	
x	y
2.2400	-2.5800
2.3300	-2.7000
2.4900	-2.8200
2.6100	-2.9200
2.7200	-3.0300
2.8600	-3.1200
3.0500	-3.2400
3.2000	-3.3100
3.4300	-3.3900
3.5700	-3.4400

4th Isochrone (U)	
x	y
2.1900	3.3400
2.3000	3.4600
2.3900	3.5800
2.5000	3.6700
2.6000	3.7400
2.7100	3.8100
2.8000	3.8700
2.8600	3.9300

4th Isochrone (L)	
x	y
1.6300	-2.9400
1.6800	-3.0300
1.7600	-3.1300
1.8400	-3.2300
1.9600	-3.3400
2.0700	-3.4500
2.1600	-3.5600
2.2400	-3.6400
2.3800	-3.7100
2.5000	-3.7700
2.6200	-3.8500
2.7400	-3.9200
2.8600	-4.0000

5th Isochrone (U)	
x	y
1.3600	3.4700
1.4300	3.6100
1.5000	3.7400
1.6000	3.8200
1.7100	3.9600
1.9100	4.1700
2.0200	4.2500
2.0600	4.3400

5th Isochrone (L)	
x	y
0.99000	-3.2900
1.0600	-3.4400
1.2000	-3.6700
1.2700	-3.7500
1.3600	-3.8500
1.4500	-3.9200
1.5600	-4.0400
1.6700	-4.1200
1.7600	-4.2000
1.8800	-4.2900
1.9800	-4.3600
2.0800	-4.4100
2.1700	-4.4700

6th Isochrone (U)	
x	y
0.67000	3.5200
0.72000	3.6500
0.77000	3.7900
0.77000	3.9000
0.81000	3.9700
0.87000	4.0500
0.95000	4.1800
1.0400	4.3100
1.0900	4.4000
1.1600	4.5100
1.2200	4.5900
1.2600	4.6300

6th Isochrone (L)	
x	y
0.29000	-3.4600
0.33000	-3.6100
0.40000	-3.8100
0.50000	-4.0100
0.57000	-4.1200
0.64000	-4.2100
0.78000	-4.3300
0.94000	-4.4500
1.0700	-4.5800
1.1700	-4.7000
1.2600	-4.8000

7th Isochrone (U)	
x	y
-0.0400	3.4900
-0.0200	3.6300
-0.0200	3.8100
0.04000	4.0100
0.07000	4.1500
0.14000	4.2600
0.18000	4.3500
0.21000	4.4200
0.27000	4.5100
0.31000	4.5900
0.35000	4.6800
0.39000	4.7300
0.41000	4.7800

7th Isochrone (L)	
x	y
-0.3600	-3.6500
-0.3600	-3.7600
-0.3100	-3.9500
-0.2200	-4.1600
-0.1200	-4.3200
-0.0600	-4.3900
0.02000	-4.5100
0.14000	-4.6500
0.21000	-4.7400
0.29000	-4.8400
0.33000	-4.9400

8th Isochrone (U)	
x	y
-0.71000	3.3300
-0.75000	3.5000
-0.76000	3.7300
-0.74000	3.9300
-0.70000	4.1100
-0.67000	4.2400
-0.63000	4.3700
-0.60000	4.4900
-0.57000	4.6800
-0.53000	4.7800
-0.52000	4.8000

8th Isochrone (L)	
x	y
-1.0900	-3.560
-1.1200	-3.640
-1.1500	-3.760
-1.1200	-3.920
-1.0800	-4.070
-0.9900	-4.210
-0.9500	-4.380
-0.8900	-4.510
-0.8000	-4.600
-0.7400	-4.710
-0.6400	-4.860
-0.6200	-4.920

9th Isochrone (U)	
x	y
-1.4000	3.0600
-1.4700	3.1900
-1.5100	3.3900
-1.5700	3.5800
-1.5500	3.7900
-1.5500	3.9400
-1.5100	4.0800
-1.5000	4.2500
-1.4200	4.3800
-1.4000	4.4800
-1.3800	4.5500
-1.3700	4.6700

9th Isochrone (L)	
x	y
-1.7100	-3.3700
-1.8100	-3.4800
-1.8500	-3.6100
-1.8900	-3.8100
-1.8901	-4.0100
-1.8300	-4.2700
-1.7800	-4.4000
-1.7100	-4.5200
-1.6900	-4.6900

10th Isochrone (U)	
x	y
-2.0100	2.7300
-2.1700	3.0100
-2.2200	3.3100
-2.2200	3.6100
-2.2500	3.9300
-2.2300	4.1400
-2.2000	4.2700
-2.1800	4.4300

10th Isochrone (L)	
x	y
-2.4600	-3.2000
-2.5400	-3.4300
-2.5500	-3.7200
-2.5400	-3.9900
-2.5501	-4.1600
-2.5400	-4.2500

11th Isochrone (U)	
x	y
-2.6500	2.3800
-2.7300	2.5900
-2.8000	2.8100
-2.9100	3.0400
-2.9900	3.2200
-3.0200	3.4300
-3.0400	3.6400
-3.0600	3.7700
-3.0400	3.9100

11th Isochrone (L)	
x	y
-2.9800	-2.6800
-3.0700	-2.7800
-3.1900	-2.9800
-3.2500	-3.1500
-3.3000	-3.3000
-3.3500	-3.4900
-3.3800	-3.6100
-3.3600	-3.7000

12th Isochrone (U)	
x	y
-3.0200	1.7900
-3.1500	1.8900
-3.4000	2.0500
-3.4600	2.2600
-3.5100	2.5400
-3.5700	2.7000
-3.6500	2.9800
-3.6900	3.1200
-3.7000	3.2700
-3.7000	3.3500

12th Isochrone (L)	
x	y
-3.4000	-2.2200
-3.5600	-2.3100
-3.7500	-2.5100
-3.8300	-2.6800
-3.9600	-2.8600

13th Isochrone (U)	
x	y
-3.4400	1.2000
-3.6500	1.3100
-3.8000	1.4900
-3.9100	1.6700
-4.0100	1.8300
-4.1100	1.9700
-4.2000	2.0900
-4.2500	2.2200
-4.3300	2.3400

13th Isochrone (L)	
x	y
-3.7200	-1.5500
-3.9500	-1.6300
-4.0900	-1.7900
-4.2000	-1.9100
-4.3700	-2.0900
-4.4300	-2.2300

14th Isochrone (U)	
x	y
-3.6900	0.5500
-3.8800	0.6100
-4.1100	0.7600
-4.3300	0.9400
-4.5100	1.1500
-4.5900	1.2600
-4.6700	1.3400
-4.7100	1.4100

14th Isochrone (L)	
x	y
-4.0300	-0.9100
-4.1400	-0.8900
-4.2000	-0.9700
-4.4300	-1.1000
-4.5600	-1.2300
-4.6600	-1.3100
-4.7500	-1.3400
-4.7900	-1.3700

15th Isochrone (U)	
x	y
-3.9000	-0.1300
-4.0700	-0.0800
-4.2500	-0.0200
-4.4300	0.0800
-4.5800	0.2600
-4.7400	0.3700
-4.8500	0.4500
-4.9600	0.5200

15th Isochrone (L)	
x	y
-3.9100	-0.2400
-4.0700	-0.2100
-4.3500	-0.2300
-4.4800	-0.3100
-4.5600	-0.3600
-4.6700	-0.4200
-4.7900	-0.4700
-4.8500	-0.4900
-4.9600	-0.5300

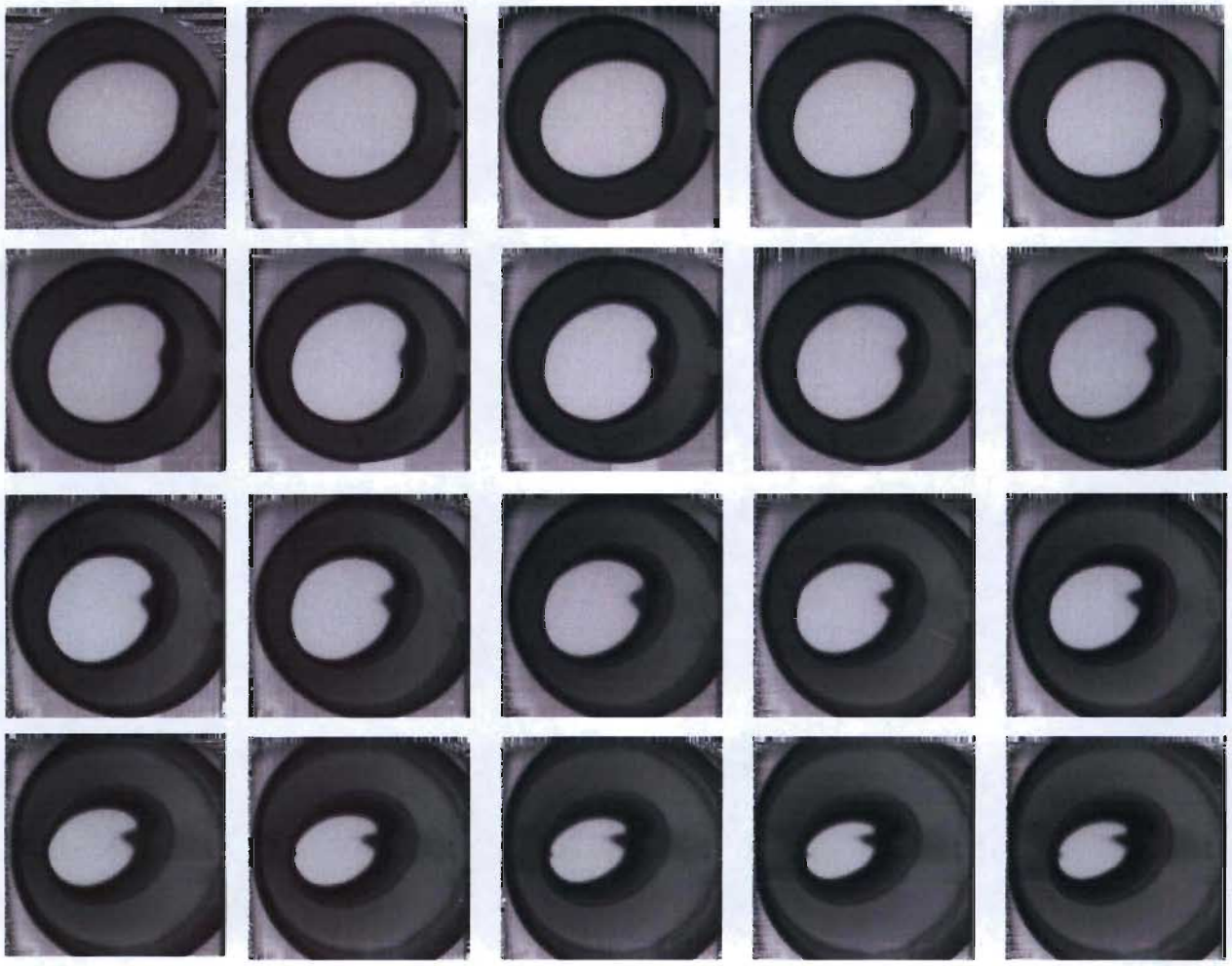

Figure 2. Proton radiographs of the Cyclops I experiment taken at 1 μs intervals. It was estimated that the first image was taken about 3.85 μs after booster initiation and the last one at 22.85 μs.