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Optics Lab Homework

2.11

To subtract two values with uncertainty, the values themselves are first subtracted, then their uncertainties are added together. For the first row of the chart:

$$(3.0 \pm 0.3) - (2.7 \pm 0.6)$$

$$(3.0 - 2.7) \pm (0.3 + 0.6)$$

The first row of the new $L - L'$ column.

$$0.3 \pm 0.9$$

The remainder of the values were generated by feeding the data from the table into the following Haskell program:

```haskell
{-
 - Given a list of initial and final values with uncertainty,
 - subtracts the final values from the initial ones.
 -}

-- ----------BEGIN TYPES----------

type Value = Float
type Uncertainty = Float

-- -----------END TYPES-----------

-- ----------BEGIN INPUT----------

-- convert initial String into list of list of numbers
getIn :: String -> [[Float]]
```

```
17 getIn s = map line2NumList (lines s)
18
19 -- converts space-delimited String into list of Numbers
20 line2NumList :: String -> [Float]
21 line2NumList s = map readFloat (words s)
22
23 -- type-safe version of read for Floats
24 readFloat :: String -> Float
25 readFloat = read
26
27 -- -----------END INPUT-----------
28
29 -- ----------BEGIN SUBTRACTION----------
30
31 -- subtract the values, and add the uncertainties
32 subtractUn :: [Float] -> (Value, Uncertainty)
33 subtractUn [iniVal, iniUn, finVal, finUn] = ((iniVal - finVal), (ini
34
35 -- -----------END SUBTRACTION-----------
36
37 -- ----------BEGIN OUTPUT----------
38
39 -- outputs all information
40 output :: [(Value, Uncertainty)] -> String
41 output ((v,u):cs) = show v ++ "␣" ++ show u ++ "\n" ++ output cs
42 output [] = ""
43
44 -- prepares processed data for output
45 dataOut :: [(Value, Uncertainty)] -> String
46 dataOut ((v,u):cs) = show v ++ "␣" ++ show u ++ "\n" ++ dataOut cs
47 dataOut [] = ""
48
49 -- -----------END OUTPUT-----------
50
51 main :: IO()
52 main = interact $ output . (map subtractUn) . getIn
```

The table can then be completed:

Initial L	Final L'	$L - L'$
3.0 ± 0.3	2.7 ± 0.6	0.3 ± 0.9
7.4 ± 0.5	8.0 ± 1	-0.6 ± 1.5
14.3 ± 1	16.5 ± 1	-2.2 ± 2.0
25 ± 2	24 ± 2	1.0 ± 4.0
32 ± 2	31 ± 2	1.0 ± 4.0
37 ± 2	41 ± 2	-4.0 ± 4.0

Figure 1: The completed table for problem 2.11, with included third column.

All results, except for the one in the third row, are consistent with the conservation of angular momentum, because the uncertainties allow the value to cross zero. In the case of the third row, the closest the uncertainty brings the value to zero is -0.2.

3.26

(a)

Since $\mu = 0.10 \pm 0.01 \text{cm}^2\,\text{g}^{-1}$, it can be determined from the graph that $E = 0.7 \pm \delta E$, where $\delta E = E(\mu_{best} + \delta\mu) - E(\mu_{best})$:

$$
\begin{aligned}
E &= 0.7 \pm (|E(\mu_{best} + \delta\mu) - E(\mu_{best}|) \\
E &= 0.7 \pm (|E((0.10) + (0.01)) - E((0.10))|) \\
E &= 0.7 \pm (|(0.65) - (0.7)|)
\end{aligned}
$$

$$\boxed{E = 0.7 \pm 0.05 MeV}$$

(b)

If $\mu = 0.22 \pm 0.01 \text{cm}^2\,\text{g}^{-1}$, then $E = 0.4 \pm \delta E$: