**物理竞赛实验光学评分标准**

  **竞赛时间：\_2017\_年\_10\_月\_29\_日；所需时间： 90 分钟**

**成绩评定表**

**一．光源波长的测量（本部分30分）**

|  |
| --- |
| **1、（16分）垂直入射测光源波长的测量****（1） 根据夫琅和费衍射理论，画出平行光垂直入射光栅时的测量光路图并写出光栅方程和方程中各个量的物理意义？（4分）**光路图：评分： 2分平行光管、光栅、望远镜、衍射级数和衍射角度的标注各0.4分光栅方程： （1）：第k级衍射光的衍射角；d：光栅常数；λ：入射光的波长 评分： 2分方程和各个字母的说明各0.4分 |

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **（2） 在分光计上进行测量时，分光计和光栅的调节要求是什么？（4分）**分光计的调节要求是：平行光管产生平行光；望远镜接受平行光；平行光管和望远镜的光轴都垂直仪器转轴，光栅平面与平行光管光轴垂直；光栅的刻痕与仪器转轴平行。评分： 4分, 每点各1分**（3） 测量光源的光谱波长，列表记录、处理数据并计算光源波长。（8分）**数据记录：（参考）

|  |  |  |
| --- | --- | --- |
| 级数 | Ⅱ级 | Ⅰ级 |
| 谱线 | 黄1 | 黄2 | 黄1 | 黄2 |
| 游标 | 游标1 | 游标2 | 游标1 | 游标2 | 游标1 | 游标2 | 游标1 | 游标2 |
| φ左（负级） | 239°45′ | 59°45′ | 239°42′ | 59°41′ | 215°27′ | 35°25′ | 215°26′ | 35°22′ |
| φ右（正级） | 149°43′ | 329°40′ | 149°48′ | 329°43′ | 174°02′ | 353°58′ | 174°03′ | 353°59′ |
| 2=|φ左-φ右| | 90°02′ | 90°05′ | 89°54′ | 89°58′ | 41°25′ | 41°27′ | 41°23′ | 41°23′ |
| 2 | 90°03′ | 89°56′ | 41°26′ | 41°23′ |
| λ(nm) | 589.51  | 588.91  | 589.58  | 588.90  |

数据处理：（参考）将衍射角代入（1）式得光源黄1的波长： 光源黄2的波长： **评分：8分****1、数据记录2分** **考试时学生不一定测两级光谱，只要数据正确，只有一级或只有二级都可；****若只测一条黄光，扣0.5分；****若只测 正级或负级和零级扣0.5分；****最小分度不在分位扣0.4分；****2、数据处理6分****标准值：****Ⅱ级：黄1的2φ值为90°04′，波长589.61nm；黄2的2φ值为89°57′，波长589.00nm；****Ⅰ级：黄1的2φ值为41°26′，波长589.58nm；黄2的2φ值为41°23′，波长588.90nm。****评分标准：**1. **黄1**

 **2φ的误差绝对值： 小于等于3′ 2分** **大于3′小于等于5′ 1分** **超出上述范围 0分****波长： Ⅱ级： 589.34～589.86nm 1分****589.17～590.03nm 0.5分****或：** **Ⅰ级： 588.90～590.26nm 1分****588.44～590.71nm 0.5分****超出上述范围 0分**1. **黄2**

**2φ的误差绝对值： 小于等于3′ 2分** **大于3′小于等于5′ 1分** **超出上述范围 0分****波长： Ⅱ级： 588.74～589.26nm 1分****588.56～589.43nm 0.5分****或：****Ⅰ级： 588.22～589.58nm 1分****587.76～~590.03nm 0.5分****超出上述范围 0分****注:****波长要和2φ对应，详见附表正入射；****若只测正级或负级和零级数据处理扣0.5分；****若波长计算错误扣0.2分；****波长有效数字不是4-5位扣 0.2分；****无单位或单位错误扣0.4分。** |
| 1. **（14分）斜入射测光源波长的测量**

**（1）根据夫琅和费衍射理论，平行光斜入射时的光栅方程和方程中各个量的物理意义是什么？方程中的角度如何测量？（2分）：**光栅方程和方程中各个量的物理意义： （2）为入射角；衍射角；当入射光线和衍射光线在光栅法线的同侧时，取“+”，异侧时取“-”；λ：入射光的波长；评分： 1分方程0.5分；**方程中各个**物理量的意义各0.1分方程中角度的测量：入射角θ指的是入射光线和光栅法线之间的夹角；衍射角φk指的是第k级衍射光与光栅法线之间的夹角；光栅反射的绿色“+”和目镜纵叉丝重合时为光栅法线的角位置；0级光谱和目镜纵叉丝重合时为入射光线的角位置；再测各级衍射光和目镜纵叉丝重合时的角位置；测出三者角位置即可测得θ和φk。评分： 1分， 5点各0.2分**（2）在平行光斜入射时，衍射光方向与入射光方向之间的夹角称为偏向角，以符号表示，有，其中、分别为光栅的入射角和衍射角。改变入射角使光栅进入斜入射状态，观察衍射光随转角的变化规律，能否找到一个特殊角度α，只要测出此角度α就能计算出光源波长？写出观察规律、测量光路图、计算公式、测量数据和计算结果。（12分）****（此处有提示卡一，用者扣8分）**观察规律：改变光栅的入射角，衍射光随入射角的改变而移动，这个过程中会出现衍射光线有一个转折现象。即入射角改变到某一位置再继续改变时，视场内衍射光不再沿原来方向移动，而开始向相反方向移动，即有一个最小偏向角αmin。偏向角与入射角和衍射角有关系，最小偏向角是极限角度，找到特殊角度αmin，测出此角度αmin，光栅常数已知就能计算出光源波长。评分： 2分1、正确对转折现象进行描述1分；2、由转折现象提出现象对应的极值偏向角1分光路图：  图2评分： 2分平行光管、光栅、望远镜和衍射级数的标注各0.2分，三个角度的标注各0.4分计算公式：提示：由斜入射公式可得：2dsin[(θ+ϕ)/2]cos[(θ-ϕ)/2]=kλ，当 时，cos值最大为1，因而偏向角最小，以符号表示，有，斜入射公式为 （3）其中为第k级衍射光的最小偏向角。评分： 2分推导过程1分；公式1分，k的范围错误或没说明扣0.5分；数据记录：（参考）

|  |  |  |
| --- | --- | --- |
| 级数 | Ⅰ级 | Ⅱ级 |
| 谱线 | 黄1 | 黄2 | 黄1 | 黄2 |
| 游标 | 游标1 | 游标2 | 游标1 | 游标2 | 游标1 | 游标2 | 游标1 | 游标2 |
| φ出 | 204°59′ | 24°55′ | 204°38′ | 24°33′ | 215°22′ | 35°18′ | 215°39′ | 35°34′ |
| φ入 | 184°37′ | 4°31′ | 184°17′ | 4°11′ | 173°56′ | 353°52′ | 174°15′ | 354°11′ |
| =|φ出-φ入| | 20°22′ | 20°24′ | 20°21′ | 20°22′ | 41°26′ | 41°26′ | 41°24′ | 41°23′ |
|  | 20°23′ | 20°22′ | 41°26′ | 41°23′ |
| λ(nm) | 589.81  | 589.33  | 589.58  | 588.90  |

数据处理：（参考）将αm代入（3）式得黄1的波长：黄2的波长：**评分：6分**1、数据记录2分不一定测两级光谱，只要数据正确只有一级或只有二级都可通过；若只测一条黄光，扣0.5分；同级黄1和黄2的入射角位置相同扣0.4分；最小分度不在分位扣0.4分；**说明：使用提示卡一，观察规律、光路图、计算公式和数据记录得分为0分。**2、数据处理4分标准值：Ⅱ级：黄1的αm值为41°26′，波长589.58nm；黄2的αm值为41°23′，波长588.90nm；Ⅰ级：黄1的αm 值为20°23′，波长589.81nm；黄2的αm 值为20°21′，波长588.85nm。评分标准：1）黄1 αm的误差绝对值： 小于等于3′ 1分 大于3′小于等于5′ 0.5分 超出上述范围 0分波长： Ⅱ级： 588.90~590.26 nm 1分588.44～590.71nm 0.5分或：Ⅰ级： 588.37~591.24nm 1分587.42～592.19nm 0.5分超出上述范围 0分2）黄2αm的误差绝对值： 小于等于3′ 1分 大于3′小于等于5′ 0.5分 超出上述范围 0分波长： Ⅱ级： 588.22~589.58nm 1分587.76～590.03nm 0.5分或：Ⅰ级： 587.42~590.28nm 1分586.46～591.24nm 0.5分超出上述范围 0分**波长要和**αm**对应，详见附表斜入射；****若同级黄1和黄2的入射角位置相同的，扣0.4分；****波长计算错误扣0.2分；****波长有效数字不是4-5位扣 0.2分**；**无单位或单位错误扣0.4分。****注意：以垂直入射计算的光源波长（取光源谱线的均值），进行未知溶液折射率的测量.** |

**二．测量未知溶液的折射率（30分）**

|  |
| --- |
| **1、（4分）说明如何区分平板玻璃和平凸玻璃？并判断出平凸玻璃的凸面，用玻璃侧面的字母A、B表示；****（1）说明区分平板玻璃和平凸玻璃的方法；（2分）**只有平凸玻璃的凸面和平板玻璃的平面紧贴，才会有明暗相间的圆环。把两块玻璃的两个面贴在一起用眼睛直接或通过显微镜观察，如果没有圆环，更换两紧贴面的其中一个面，直至观察到明暗相间的圆环，则两个面中有一个面为凸面；转换上面玻璃的另一面后再贴在一起观察，如果仍有圆环，则上面玻璃为平板玻璃，下面玻璃为平凸玻璃且其上面为凸面，否则上面玻璃为平凸玻璃且翻转后的上面为凸面，下面玻璃为平板玻璃。评分： 2分**（2）判断出平凸玻璃的凸面，用玻璃侧面的字母A、B表示。（2分）****平凸玻璃的侧面字母标号： B** **（在标号右侧画出箭头符号，以箭头指向表示平凸玻璃的凸面，例如D 表示D玻璃的下面为凸面 ）**评分： 2分**2、（8分）写出测量未知溶液折射率的原理和公式、光路图，说明公式中各个量的物理意义；** **（此处有提示卡二，用者扣8分）**光路图：图3 原理和公式：设平凸透镜凸面的球面半径为R，第级暗纹的半径为，而该环纹处对应的介质膜(折射率为n′)厚度为。则由牛顿环等厚干涉条件可得到干涉暗纹条件：  （4）k为暗纹级数图3中几何关系看出：  (5)因，上式的项可忽略，因此得：  将值代入干涉暗纹条件化简得：  (6)中心暗环的级数用m0表示，半径用直径代替，上式为：  （7）由上式可以推导出未知溶液折射率的公式为：  (8)说明公式中各个量的物理意义：n未:未知溶液折射率；R：平凸透镜凸面的球面半径；m、n：相对中心暗斑的暗环级数；、分别是第m级与第n级暗环的直径的平方；λ：光源波长。评分： 8分1、正确画出光路图 2分（暗纹的半径为、环纹处对应的介质膜(折射率为n′)、介质膜对应厚度为、光线的方向、R未标出各扣0.2分）2、原理和公式（公式（4）、（5）、（6）、（7）或者（8））4分（4个公式和原理各1分）3、说明2分（各0.4分）4、使用提示卡二不得分**3、（4分）画出实际测量时各仪器的光路示意图；(即光源、读数显微镜、各个光学元件之间的光路示意图)；** 图4评分：4分需要标出各个仪器和元件名称，位置和元件名称各0.8分（载物台包含在读数显微镜里） |

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **4、（6分）若空气的折射率n0=1.0003，测量平凸玻璃凸面的球面半径，列表记录实验数据并处理数据；**数据记录：（参考）

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| i | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
| m | 16 | 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 |
| D左（mm） | 21.682 | 21.553 | 21.419 | 21.273 | 21.129 | 20.987 | 20.824 | 20.652 | 20.477 | 20.283 | 20.092 | 19.872 |
| D右（mm） | 13.475 | 13.609 | 13.749 | 13.882 | 14.026 | 14.173 | 14.328 | 14.496 | 14.669 | 14.858 | 15.051 | 15.270 |
| D（mm） | 8.207 | 7.944 | 7.670 | 7.391 | 7.103 | 6.814 | 6.496 | 6.156 | 5.808 | 5.425 | 5.041 | 4.602 |
| Dm2（mm2） | 67.35 | 63.11 | 58.83 | 54.63 | 50.45 | 46.43 | 42.20 | 37.90 | 33.73 | 29.43 | 25.41 | 21.18 |

评分：2分 1、测量级数>10级满分、9级扣0.2分、8级扣0.4分、7级扣0.6分、6级扣0.8分、5级扣1分、4级或小于4级扣1.2分2、数据有效数字错误扣0.4分3、无单位或单位错误扣0.4分数据处理：**逐差法：**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| i | 10 | 9 | 8 | 7 | 6 | 5 | 平均值 |
| Di+62 –Di2（mm2） | 25.16  | 25.21  | 25.10  | 25.20  | 25.04  | 25.25  | 25.16 |

**=1779.7mm****最小二乘法：**公式(7)中，设x=m，y= Dm2

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| i | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 平均值 |
| m | 16 | 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 10.5 |
| m2 | 256 | 225 | 196 | 169 | 144 | 121 | 100 | 81 | 64 | 49 | 36 | 25 | 122.17 |
| Dm2（mm2） | 67.35 | 63.11 | 58.83 | 54.63 | 50.45 | 46.43 | 42.20 | 37.90 | 33.73 | 29.43 | 25.41 | 21.18 | 44.22 |
| mDm2（mm2） | 1077.7  | 946.6  | 823.6  | 710.1  | 605.4  | 510.7  | 422.0  | 341.1  | 269.9  | 206.0  | 152.5  | 105.89  | 514.3 |

  R=1780mm评分： 4分1、测量值在标准值1791mm

|  |  |
| --- | --- |
| **标准值** | **1791mm** |
| **4分 ±28 mm**  | **1763 ~1819 mm** |
| **2.8分 ±56 mm**  | **1735 ~1762 mm 1820 ~1847 mm** |
| **1.4分 ±84 mm**  | **1707 ~1734mm 1848 ~1875 mm** |
| **0分** | **其它** |

2、公式错误扣0.4分3、有效数字为4-5位，否则扣0.4分4、数量级与单位不符或无单位扣0.4分**5、（8分）测量未知溶液的折射率，列表记录实验数据，处理数据和结果。**数据记录：（参考）

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| i | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
| m | 16 | 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 |
| D左（mm） | 29.246 | 29.123 | 29.019 | 28.896 | 28.763 | 28.629 | 28.493 | 28.344 | 28.188 | 28.018 | 27.839 | 27.637 |
| D右（mm） | 22.274 | 22.391 | 22.509 | 22.629 | 22.759 | 22.892 | 23.032 | 23.174 | 23.327 | 23.492 | 23.66 | 23.867 |
| D（mm） | 6.972 | 6.732 | 6.510 | 6.267 | 6.004 | 5.737 | 5.461 | 5.170 | 4.861 | 4.526 | 4.179 | 3.770 |
| Dm2（mm2） | 48.61 | 45.32 | 42.38 | 39.28 | 36.05 | 32.91 | 29.82 | 26.73 | 23.63 | 20.48 | 17.46 | 14.21 |

评分：2分1、测量级数>10级满分、9级扣0.2分、8级扣0.4分、7级扣0.6分、6级扣0.8分、5级扣1分、4级或小于4级扣1.2分 2、数据有效数字错误扣0.4分3、无单位或单位错误扣0.4分数据处理：**逐差法：**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| i | 10 | 9 | 8 | 7 | 6 | 5 | 平均值 |
| Di+62 –Di2（mm2） | 18.79  | 18.59  | 18.75  | 18.79  | 18.58  | 18.70  | 18.70 |

结合上表 =1.346 **或者比较法** **最小二乘法：**公式(7)中，设x=m，y= Dm2

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| i | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 平均值 |
| m | 16 | 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 10.5 |
| m2 | 256 | 225 | 196 | 169 | 144 | 121 | 100 | 81 | 64 | 49 | 36 | 25 | 122.17 |
| Dm2（mm2） | 48.61 | 45.32 | 42.38 | 39.28 | 36.05 | 32.91 | 29.82 | 26.73 | 23.63 | 20.48 | 17.46 | 14.21 | 31.41 |
| mDm2（mm2） | 777.7  | 679.8  | 593.3  | 510.6  | 432.6  | 362.0  | 298.2  | 240.6  | 189.0  | 143.4  | 104.8  | 71.06  | 366.9 |

则： 评分： 6分1、测量值在标准值1.356

|  |  |
| --- | --- |
| **标准值** | **1.356** |
| **6分 ±0.014** | **1.342~1.370** |
| **4分 ±0.027** | **1.329~1.341 1.371~1.383** |
| **2分 ±0.041** | **1.315~1.328 1.384~1.397** |
| **0分** | **其它** |

1. 公式错误扣0.4分，
2. 有效数字取4位，否则扣0.4分
3. 加单位扣0.4分

  |