《积分视场光谱仪》教案

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一、教学目标：

1. 了解积分视场光谱仪的原理
2. 了解IFS的结构和data-cube
3. 了解IFS的应用，MUSE

二、教学重难点：

data-cube 和 IFS结构

三、学习者分析

大学三年级天文专业本科生，少数跨选或者辅修天文学的理科大三和大四本科生

四、教学准备

多媒体教室，PowerPoint 课件

五、教学过程

1. 教学时间安排（总时长 10’）
   1’导入
   3’什么是IFS
   1’为什么有人会造IFS
   3’IFS应用
   2’ 视频放送
2. 导入课程

   我想大家应该都记得滤波片是干什么的，我们对于一个天体进行观测，可以用不同滤波片挡住光路，我们就可以以此得到不同波长的单色光图像，但是这样做有一个非常大的不便，就是我们要得到一张图像就需要观测一次，对于暗弱天体我们还需要进行长时间曝光，这个过程就显得十分漫长，那么我们能不能实现一次观测就可以得到图像和光谱信息呢？

   当然可以！今天就为大家介绍能完成大家这一想法的仪器：积分视场光谱仪。

3. 什么是IFS

   lenslet array：The input image is split up by a microlens array (MLA). Light from each element of your observed object is then concentrated into a small dot and dispersed by the spectrograph. Because the dots are small it is possible to tilt the MLA about the optical axis of the system so that the spectra do not fall on top of each other, thus allowing the input image to be sampled contiguously (differentiating this technique from slit-less spectroscopy). The disadvantage is that the length of spectrum that can be produced without overlapping is very small and the packing of the CCD is not that efficient. [1]

   微透镜阵：输入图像被微透镜阵列（MLA）分割。从你观察到的物体的每一个元素发出的光，然后被浓缩成一个小点，然后被光谱仪分散。因为点是小的，所以可以使MLA关于系统的光轴倾斜，使得光谱不落在彼此的顶部，从而允许输入图像连续地采样（将该技术与狭缝光谱学区别开来）。缺点是不重叠产生的光谱长度很小，CCD的封装效率不高。

Fibres (with or without lenslets):this is currently the most common technique in use. The input image is formed at the entrance to a 2D bundle of optical fibres which transfer the light to the slit of the spectrograph. The flexibility of the fibres allows the round/ rectangular field-of-view to be reformatted into one (or more) "slits", from where the light is directed to the spectrograph, and the spectra are obtained without wavelength shifts between them. The disadvantages of this techniques are: (a) the sampling of the sky is not contiguous since there are gaps between the fibre cores (fibres are cylindrical) and (b) the fibres do not work efficiently at the slow focal ratios at which most telescopes work resulting in focal ratio degradation (FRD). Disadvantage (a) can be overcome by placing an array of contiguous lenslets in front of the fibre bundle in order to focus all the light collected by that lenslet into the fibre (lenslet shapes are usually square or hexagonal and thus can be packed contiguously). An additional benefit of this variation is that the microlenses slow the telescope focal beam so that FRD can be minimised. [2][3]

纤维：这是目前最常用的技术。输入图像在将光传输到光谱仪狭缝的二维光纤束的入口处形成。纤维的柔韧性使圆形/矩形视场被分成一个（或多个）狭缝，从光线指向摄谱仪，光谱在没有波长偏移的情况下获得。这种技术的缺点是：（a）由于光纤芯之间存在间隙（光纤为圆柱形），天空采样不连续；（b）光纤在大多数望远镜工作时的慢焦比下无法有效工作，导致焦比下降（FRD）。缺点（a）可以通过在光纤束前面放置一组相邻的透镜来克服，以便将该透镜收集的所有光聚焦到光纤中（透镜形状通常为正方形或六角形，因此可以连续地填充）。这种变化的另一个好处是，微透镜使望远镜的焦距光束变慢，从而使FRD最小化。

Image-slicer:The input image is formed on a mirror that is segmented in thin horizontal sections, sending each 'slice' in slightly different directions. A second segmented mirror is arranged to reformat the slices so that, instead of being above each other they are now laid out end to end to form the slit of the spectrograph. The advantage of this technique is that FRD is avoided and the slicing arrangement gives contiguous coverage of the field at potentially high spatial resolution. Because this system uses only mirrors, it is especially suitable for the infrared since it is inherently achromatic and can be cooled to cryogenic temperatures. Potential disadvantages are: (a) that the sampling along the slices is the same as that provided naturally by the telescope meaning there is reduced scope to include a slicer within a spectrograph that must also have a normal long-slit mode and (b) the optical system might be bulky and difficult to fabricate. [4]

image-slicer：输入图像是在一个镜子上形成的，这个镜子被分割成很薄的水平部分，将每个“部分”发送到稍微不同的方向。另一个分段镜被布置成重新格式化这些切片，这样，它们现在不是彼此上方而是端对端地布置，以形成光谱仪的狭缝。该技术的优点是避免了FRD，并且切片安排在潜在的高空间分辨率下提供了场的连续覆盖。因为这个系统只使用反射镜，所以它特别适合红外线，因为它本身是无色的，可以冷却到低温。潜在的缺点是：（a）沿切片的取样与望远镜自然提供的取样相同，这意味着在光谱仪中包括切片器的范围缩小，切片器也必须具有正常的长狭缝模式；（b）光学系统可能体积庞大，难以制造。

4. MUSE简介：

MUSE是multiple units spectroscopy explorer，在希腊神话中muse是代表智慧的女神们，其中图中的Uranis是天文学女神，具体有关情况我们可以看一下视频。

参考文献：

[1] Integral field spectroscopy with the Gemini Multiobject Spectrographs[EB/OL]

[2] 3D spectrography at high spatial resolution. I. Concept and realization of the integral field spectrograph TIGER. [EB/OL]

[3] DensePak and spectral imaging with fiber optics. [EB/OL]

[4] An original image slicer designed for Integral Field Spectroscopy with NIRSpec/JSWT [EB/OL]