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费米耀变体的自动分类和能谱拟合问题的研究

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耀变体是活动星系核的一个具有极端观测性质的子类, 耀变体是目前已知的宇宙中辐射最强最持久的天体, 其辐射包括电磁辐射以及中微子辐射. 费米大视场望远镜的发射对耀变体的研究作出了极大的贡献, 自从其2008年发射至今已经公布的4代源表包括了3000多个耀变体的伽马波段观测数据. 本文中将分别从数据的统计分析, 耀变体全波段SED (spectral energy distribution)拟合, 以及MeV波段探测的设计模拟出发对耀变体进行全面的研究.

首先, 针对费米三期源表(3FGL)中的未分类耀变体(BCU)源, 我们基于机器学习理论建立一套利用3FGL中关于能谱的信息生成集成机器学习方法, 对3FGL中的573个BCUs进行预测分类. 我们的集成机器学习方法准确率达到92.13%, 我们将573个BCUs预测为326个蝎虎天体(BL Lac)和247个平谱射电类星体(FSRQ). 通过与其他学者方法得到的结果相比较, 证实了我们方法得到的结果是可信的, 因此我们的集成机器学习方法很可靠且有效, 同时我们的准确率更高. 利用这种机器学习方法得到的结果有助于指导光学证认观测.

其次, 我们的分类工作中发现, 最终影响分类结果的参数主要都是描述源SED能谱信息的参数. 以这一点作为指引, 我们深入研究耀变体的SED, 聚焦在喷流的本征机制以及这些机制是否导致了FSRQ和BL Lac能谱差异. 我们拟合了344个耀变体的全波段SED, 并且对每个源提供了描述能谱的6个参数和描述辐射区的9个参数的参考值. 研究结果表明BL Lac喷流辐射区中的电子平均能量高于FSRQ中的电子平均能量, 同时BL Lac也存在更强的Klein-Nishina效应. 此外, FSRQ和BL Lac拥有不同的软光子环境, 其喷流中粒子的加速机制不相同都是导致他们能谱差异的原因.

最后, 通过对耀变体SED的研究发现在耀变体SED的兆电子伏特能量(MeV)范围没有观测数据, 其原因是目前没有在该波段运行的望远镜. MeV波段的数据对于决定SED的谱形十分重要, 此外, 逆康普顿峰值落在MeV波段的耀变体是非常特别的一类耀变体, 我们认为这类源的能谱与被费米望远镜发现的耀变体的能谱有显著不同. 我们设计了一个MeV波段探测器, 并通过数值模拟来考察它的性能. 主要是涉及一个运行在近地轨道上的MeV波段探测器的"探路者", 大小为2U (10 cm × 10 cm × 20 cm). 数值模拟的结果表明, 这种大小的探测器很难探测到MeV波段的耀变体辐射. 如果想要探测到耀变体的MeV波段能谱, 在性能保持稳定的情况下, 探测器的大小应至少为10 U.

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Automated Classification and Spectral Modeling of *Fermi* Blazars

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Blazars, an extreme subclass of active galactic nuclei (AGNs), are the most persistent cosmological objects that emit electromagnetic radiation and neutrino radiation. *Fermi*-LAT (*Fermi* Large Area Telescope) has made great contributions to the research of blazars, and it has released 4 generations of point source catalogues since it was launched in 2008. This thesis aims to make an extensive study of blazars and its content covers a few aspects, including data analysis, spectral energy distribution (SED) modelling and the concept design of a MeV detector.

Firstly, we generated a new machine learning (ML) method to identify those unclassified *Fermi*-LAT third source catalogue (3FGL) uncertain class of blazars (BCUs) as either flat-spectrum radio quasars (FSRQs) or BL Lacertae objects (BL Lacs) based on their spectra information in the 3FGL. Our ML method has an accuracy of 92.13%, we managed to predict 573 BCUs to 326 BL Lacs and 247 FSRQs. Comparisons between the results from our method and those from others' works indicated our method is well-performed and efficient. The identification results can guide further optical observation to confirm their classification.

Then, we notice that the main factor affecting the classification of a blazar is its spectra difference. In order to further study the intrinsic mechanism of the jet dynamic property that determines their spectra difference between FSRQs and BL Lacs, we study blazar broadband SED. We modelled 344 blazar broadband SEDs and provided a series of reference parameters, 6 parameters to describe the SED shape and 9 parameters to describe the dissipation region. These results indicate that the BL Lacs has higher average electron energy and also shows a stronger Klein-Nishina effect than FSRQs. Besides, the FSRQs and BL Lacs have different photon environment and show different particle acceleration mechanisms in the jet.

At last, we noticed that lack of telescope operating at MeV band is blamed for the incomplete SED of blazars. MeV band is very important to determine SED shape, in addition, the MeV peaked blazar is a subclass of blazars that are expected to show substantial features in their spectra compared to the *Fermi* detected blazars. We made a study of MeV detector design and performance simulation. The original design of this MeV telescope is 2U (10 cm $\times$ 10 cm $\times$ 20 cm) to work as a pathfinder in a low-Earth orbit. The simulation shows that the 2U MeV detector is too small to detect flare state blazar in the MeV band. To detect the MeV band spectrum, the detector must be at least 5 times larger.