

Hunting for Planetary Nebulae online
通过网上在线巡天图片搜寻行星状星云
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Since late-2015 I have been actively hunting for unknown Planetary Nebula (PN) candidates using publically available images online. In this section I discuss my method of hunting, demonstrated by various examples of known Planetary Nebulae, and Planetary Nebula candidates.

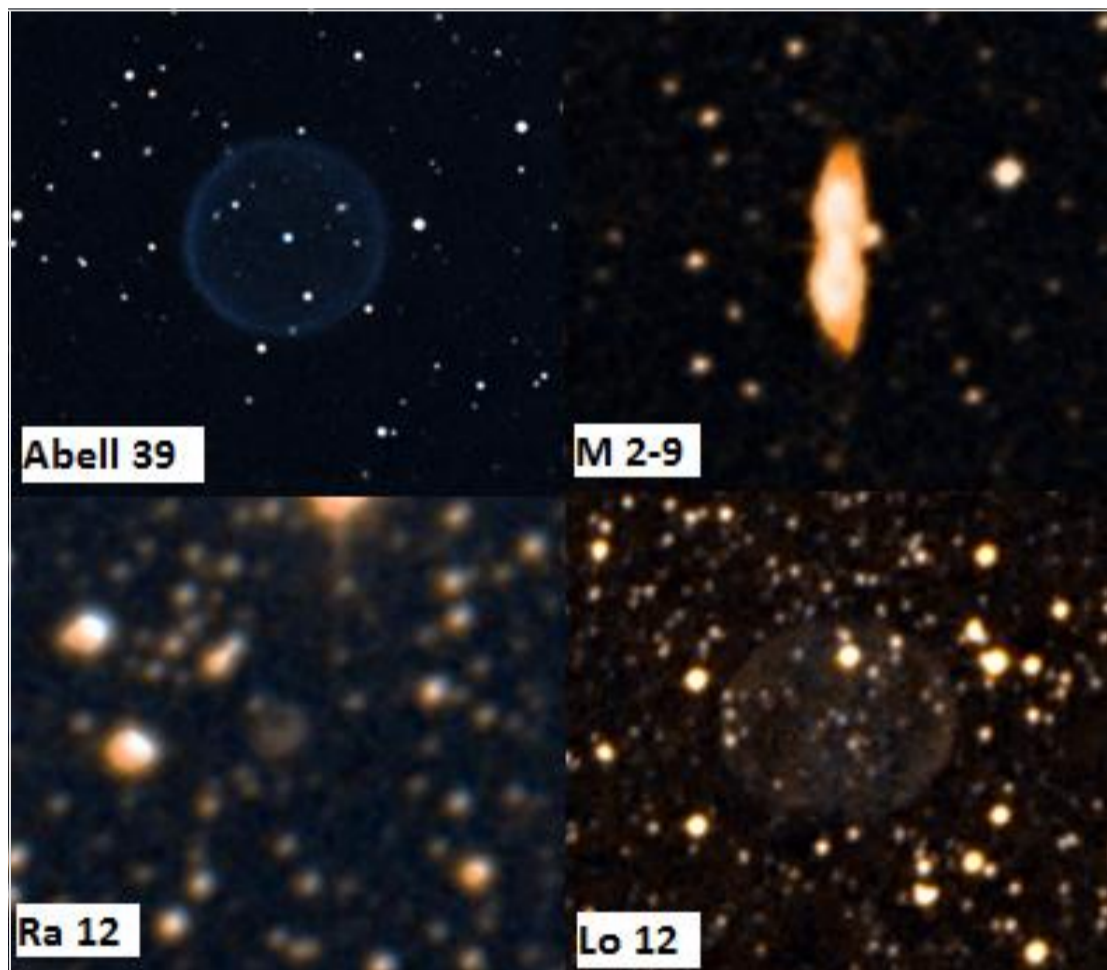
自 2015 年末以来, 我一直在网上使用公开的图片积极寻找未知的行星状星云(PN)。在这一节中, 我将讨论我的搜索方法, 通过各种已知行星状星云和行星状星云候选行星的例子进行讲解。

DSS, SDSS and Pan-STARRS1

DSS, SDSS 和 Pan-STARRS1 图片

In DSS (Digitalized Sky Survey) I hunt for well defined nebulae with typical PNe-like morphologies. The image just below shows some common recurring structures.

在 DSS(Digitalized Sky Survey)中, 我寻找具有典型的 PNe 形态的星云。下面的图像显示了一些常见的结构。



Examples of Planetary Nebulae showing typical PN-like morphologies in DSS2 (Red+Blue) images: Circular/annular, bipolar, compact quasi-stellar, and elliptical. Image credit: DSS2/Aladin Lite.

在 DSS2(Red+Blue)图像中显示典型形态的行星状星云的例子:圆形/环形、双极喷流、恒星状和椭圆。图片来源:DSS2 / Aladin Lite。

Often PNe can appear more contrasted in some parts more than others, likely due to the nebula interacting with Interstellar Matter (ISM). This can cause PNe to appear “asymmetric” or even irregular. For example, circular and elliptical PNe might appear like “arcs” instead of showing a complete “annular” structure.

通常 PNe 在某些部分的表现比其他部分更明显，可能是由于星云与星际物质(ISM)的相互作用。这可能会导致 PNe 形态出现“不对称”甚至是不规则的。例如，圆形和椭圆形的 PNe 可能看起来像“弧”，而不是显示一个完整的“环形”结构。



Two likely well evolved PNe as seen in DSS2 (Red+Blue) images, their morphology is clearly asymmetric. Images from Aladin Lite.

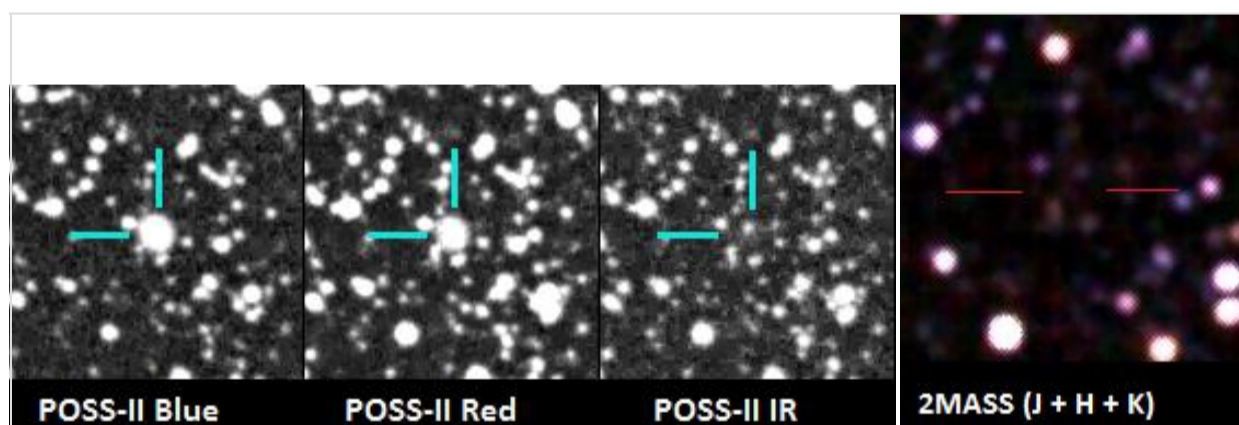
在 DSS2(red+blue)图像中，有两种可能会进化成 PNe，它们的形态是不对称的。图像来自 Aladin Lite。

Another common morphology are “stellar PNe”, but these are difficult to find in DSS as they (by definition) blend well with the background star field. These usually display particular colors when seen in SDSS and Pan-STARRS1 images (see below).

另一种常见的形态是“恒状 PNe”，但在 DSS 中很难找到它们(因为解析度的原因)与背景星场融为一体。这些通常在 SDSS 和 Pan-STARRS1 图像中显示特定的颜色(见下图)。

I also make sure the candidate is fainter in DSS2-IR and 2MASS images, in comparison to the Optical DSS plates. This is a common characteristic of PNe.

我还发现在 dss2 - ir 和 2MASS 图像中，与光学 DSS 相比，候选体显得更弱更暗。这是 PNe 的一个共同特征。



Planetary Nebula **Pa 1** as seen in DSS plates and 2MASS. Despite being obvious in the DSS Red and Blue plates, it's barely detectable in the DSS2-IR image and 2MASS. Images are from the SuperCosmos Sky Survey and Aladin Lite.

行星状星云 Pa 1 在 DSS 和 2MASS 中可见。尽管在 DSS Red 和 Blue 波段中很明显，但在 dss2 - ir 图像和 2MASS 中几乎无法看到。图片来自 SuperCosmos Sky Survey 和 Aladin Lite。

Unfortunately, many objects can mimic the morphology of PNe, especially in DSS images. These are commonly Galaxies and other kinds of nebulae (cometary globules for example). The imposters might even appear faint or absent in DSS2-IR images. Luckily SDSS and Pan-STARRS1 data can be used distinguish between the two.

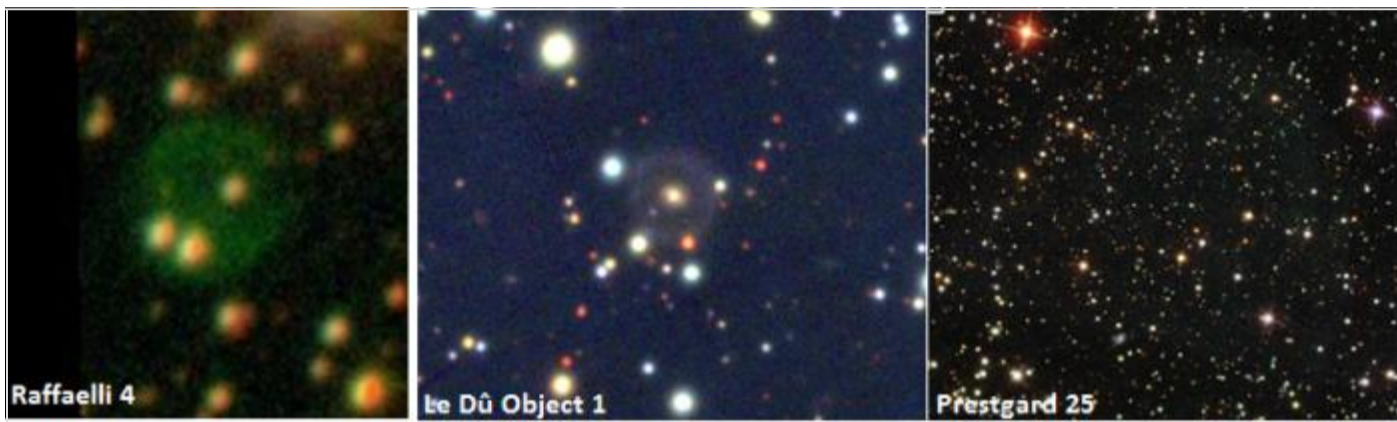
不幸的是，许多物体都有类似 PNe 的形态，尤其是在 DSS 图像中。这些通常是星系和其他种类的星云(例如彗星球状体)。在 DSS2-IR 图像中的假目标甚至会非常暗淡或不可见。幸运的是，可以使用 SDSS 和 Pan-STARRS1 数据来区分两者。

Combined color images from Pan-STARRS1 and the SDSS can be used to distinguish between true PN candidates (and other mimics) as PNe display very particular colors in these images. In SDSS and Pan-STARRS1 (g + r + i) they will appear blue or green*. More precisely, in Pan-STARRS a PN will typically well defined in the “g” and/or “r” band, but poorly visible in the “i” and “y” bands (similar to DSS2-IR). They may appear better in the “z” band though. It is because of these properties that SDSS has often been used as a good tool for PN hunting.

由于 PNe 在这些图像中有非常特殊的颜色，所以可以使用 Pan-STARRS1 和 SDSS 的组合彩色图像来区分真实 PN 候选（和其他模拟物）。在 SDSS 和 Pan-STARRS1 (g + r + i) 中，它们将呈现蓝色或绿色*。更准确地说在 Pan-STARRS 中 PN 通常在“g”和/或“r”波段中会非常明显，但在“i”和“y”波段（类似于 DSS2-IR）中会看不到。他们可能在“z”波段中会更加明显。正是由于这些属性，SDSS 通常被用作 PN 狩猎的好工具。

* This works when the “g” band is color-coded Blue, “r” as green and “i” as red.

*“g”为蓝色，“r”为绿色，“i”是红色的。

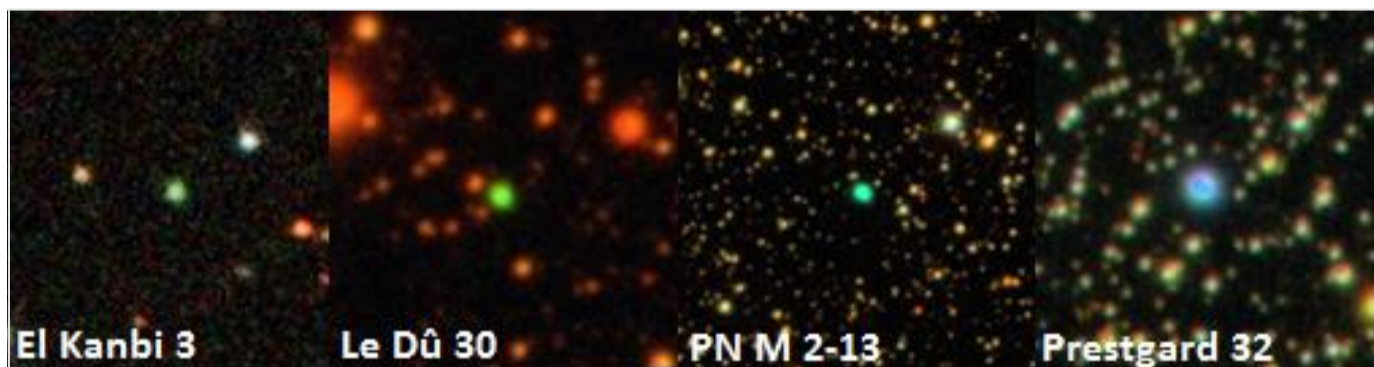


An example of a nearly circular PN in SDSS (**Ra 4**) and two counter examples: **LDû Object 1** (a likely annular galaxy) and **Pre 25** (Likely Cometary Globule). Images from Aladin Lite and the Pan-STARRS1 science consortium.

在 SDSS 中有一个圆形 PN 的例子(Ra 4)和两个反例:LDu Object 1(可能是环状星系)和 Pre - 25(可能是彗形球状体)。图片来自来自 Aladin Lite 和 Pan-STARRS1。

This technique applies very well to “stellar” PNe too. These objects might appear as green, turquoise or oddly blue stars in SDSS images.

这种技术同样适用于“恒星”PNe。这些物体可能在 SDSS 图像中显示为绿色、绿松石色或奇怪的蓝色恒星。



Some examples of “stellar” Planetary Nebulae in SDSS images. Notice their interesting green – blue tint. Images from Aladin Lite.

在 SDSS 图像中，一些“恒星”行星状星云的例子。注意他们是有趣的绿色-蓝色。图像来自 Aladin Lite。

I will then study the targets in Halpha images (from IPHAS and/or the UKST, if available) to see if they have unusually strong emissions in the Halpha band, as this is the case of most PNe. In fact, some Planetary Nebulae might be too faint to appear in DSS and/or SDSS images, but might be obvious in Halpha images (see below).

那么我可以研究 Halpha 图像中的目标（来自 IPHAS 和/或 UKST，如果可用的话）看看它们是否在 Halpha 频带中有非常强显现，因为大多数 PNe 都是这种情况。事实上，一些行星状星云可能在 DSS 和/或 SDSS 图像中显得太过微弱，但在 Halpha 图像中可能是明显的(见下文)。

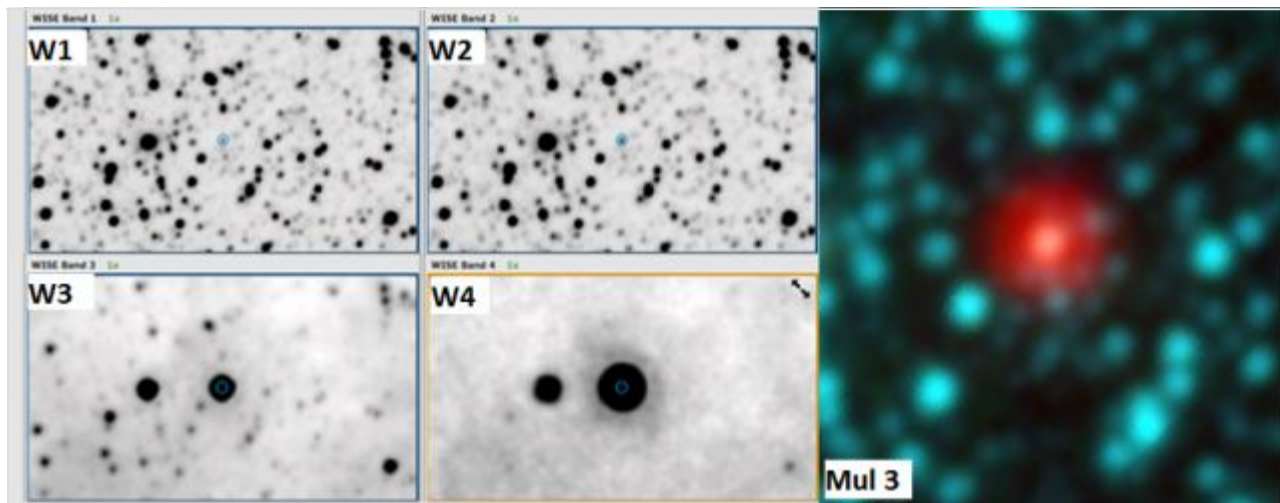
I also make sure the nebula appears best in the filters W3 and W4 from the WISE telescope (see below). However, not all PNe are visible in WISE, this is often the case of larger PNe.

我还确认了这个星云在 W3 和 W4 从 WISE 望远镜(见下图)中表现得最好。然而，并非所有的 PNe 都是可见的，通常是较大的 PNe 会是这样的。

(All)WISE

In these images I hunt for any objects with unusually strong emissions in WISE's W4 (22 micron) band. PNe tend to appear very bright in this band (as well as in W3 sometimes) in comparison to the W1 (...) and W2 WISE bands. For this I use Aladin Lite's combined (W1+W2+W4) AllWISE images.

在这些图像中，我寻找任何在 WISE W4(22 微米)波段中通常会产生强烈辐射的物体。与 W1(...)和 W2 的波段相比，PNe 在这一波段(有时甚至是 W3)显得非常明亮。为此，我使用 Aladin Lite 来组合(W1+W2+W4)所有的图像。

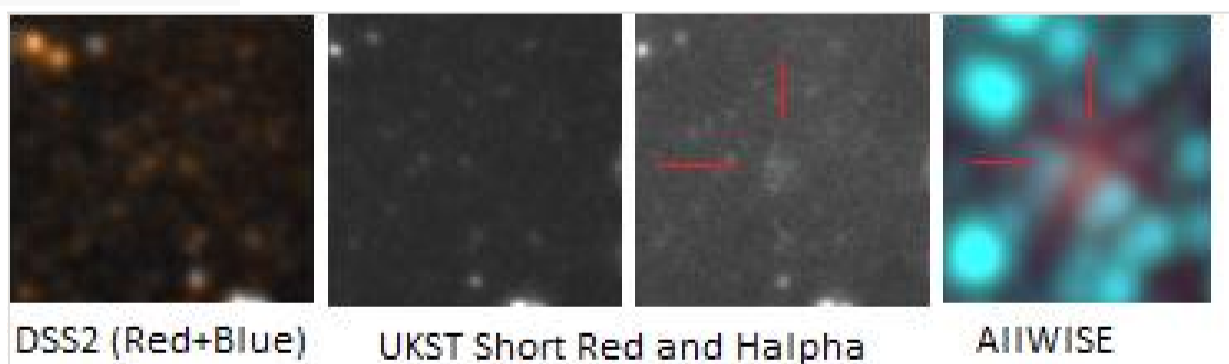


Individual WISE band frames showing Planetary Nebula candidate **Mul 3**(marked by the blue circles). The object appears essentially in the W3 and W4 bands. There are only faint traces of it in W2 and W1. This is typical of PNe. Images from WISE/IRSA.

行星状星云候选 **Mul 3**(由蓝色圆圈标记)。这个候选体在 W3 和 W4 图中明显。在 W2 和 W1 中只有微弱的痕迹。这是典型的 PNe 特征。图片来自 WISE/IRSA。

An advantage of the (All)WISE images is that it can reveal very faint PNe that might not be detectable in DSS and/or SDSS images. This is the case of PN candidate Pre 12.

(All)WISE 图像的一个优点是它可以显示非常微弱的 PNe，在 DSS 和/或 SDSS 图像中可能无法检测到。这是候选体 Pre 12 的情况。

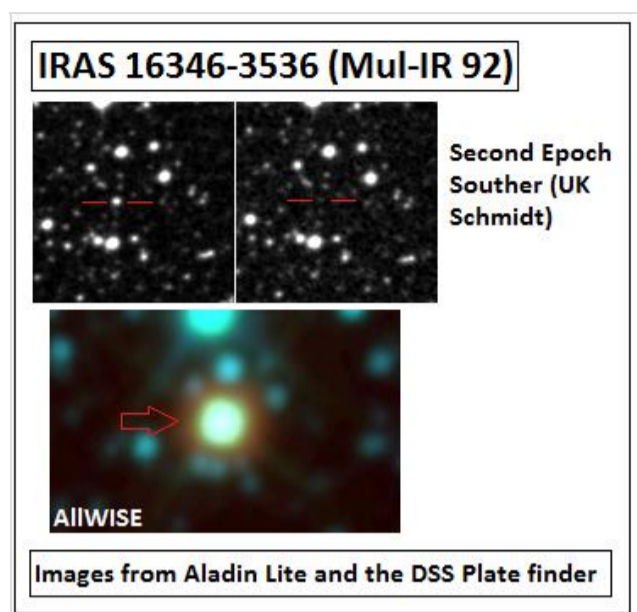


Planetary Nebula candidate **Pre 12**, a small diffuse nebula visible only in UKST/Halpha images, with a PN-like signature in the WISE W4 band. Images are from Aladin Lite and SuperCosmos Halpha Sky Survey.

行星状星云候选体 **Pre 12**，一个只有在 ukst/halpha 图像中可见的小弥散星云，在 WIES 的 W4 波段中有一个类似 pn 的特征。图片来自 Aladin Lite 和 SuperCosmos Halpha Sky Survey。

However, like for the DSS images, WISE images show many PN mimics, most notably OH/IR stars, Young Stellar Objects (YSOs), Active Galactic Nuclei (AGNs) and Proto-Planetary Nebulae. One way YSOs and OH/IR stars *often* differ from PNe is the presence of high-amplitude variability (by a few magnitudes). This is the case of Mul-IR 92 (see below).

然而，就像 DSS 的图像一样，WISE 图像显示了许多类似 PN 的情况，最常见的是 OH/IR 恒星，年轻的恒星物体(YSOs)，活跃的星系核(AGNs)和原行星状星云。YSO 和 OH/IR 恒星通常与 PNe 不同的是，存在高振幅光变变化(只有几个星等)。这是 mulir 92(见下图)的情况。



Discovery images showing the variable nature of **Mul-IR 92**. Image credit: Trygve Prestgard.
图像显示了 **Mul-IR92** 的光变性质。图片来源:Trygve Prestgard。

Mul-IR 92 appears to be a highly variable object, varying by ~ 4 magnitudes in the Red band. Such strong variations are not really in favor of a Planetary Nebula unfortunately, despite the rather favorable WISE signal. The object is now also currently listed as a possible YSO candidate by AAVSO.

Mul-IR 92 似乎是一个大幅度光变的目标，在红外波段中有 4 个不同的星等。不幸的是，尽管有相当明确的信号，但这种强烈的变化并不真正地支持它是一个行星状星云。该目标现在也被 AAVSO 列为可能的 YSO 候选对象。