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# DUST PARTICLES ON A PHOTON DIET IN V605 AQL

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RESUMEN

Presentamos un nuevo modelo para explicar los excesos en el infrarrojo cercano y medio de V605 Aql. Este objeto, pobre en hidrógeno, es de especial interés porque se formó después de un pulso tardío de He de la estrella central de la nebulosa planetaria Abell 58. Modelos sencillos para los tamaños de los granos de polvo, en equilibrio de temperatura, no pueden explicar las mediciones de ISO y IRAS. Se discuten las condiciones ambientales y los parámetros de los granos para ampliar los modelos estándares con fluctuaciones de temperatura y distribución de los granos de polvo.

ABSTRACT

We present a new model to explain the excess in mid and near infrared emission of V605 Aql. This hydrogen poor object is of special interest because it formed after a late helium flash of the central star in the planetary nebula Abell 58. Simple grain size models with an equilibrium dust temperature cannot explain ISO and IRAS measurements. Environmental condition and grain parameters are discussed to extend standard models with temperature fluctuations and a grain size distribution.

*Key Words:* **CIRCUMSTELLAR MATTER — DUST, EXTINCTION — METHODS: NUMERICAL — PLANETARY NEBULAE: INDIVIDUAL (V605 AQL)**

## 1. INTRODUCTION

Sometimes central stars of planetary nebulae (PNe) experience a final thermal pulse (Iben et al. 1983) after the object has already started the descent on the cooling track towards the white dwarf region in the Hertzsprung-Russell diagram (HRD). Theoretical calculations show that all of the remaining hydrogen is incorporated into a helium burning shell (Bloecker 1995), and for a short time the object expands to dimensions of an asymptotic giant branch (AGB) star. The evolution is very fast, and only three stars are identified members of this very rare group of objects: Sakurai's object, FG Sagittae, and V605 Aql.

The evolution of V605 Aql, the central star in the planetary nebula Abell 58 (A58), is reviewed by Clayton & de Marco (1997). The late helium flash of the central star of A58 ignited in 1919 when it was misidentified as a nova. Seitter (1987) took a spectrum of the central knot and derived physical conditions for the inner and outer nebula. However, more recent abundance determinations can be found in Guerrero & Manchado (1996).

ISOCAM observations by Kimeswenger, Kerber, & Weinberger (1998) yield bright mid and near infrared (MN-IR) emission from a newly formed dust shell around the central star, which cannot be explained with a simple dust emission model and equilibrium temperatures. However, the extreme 1 $\mu$m to 3 $\mu$m excess is caused by a misidentification in the NIR photometry in the past (see Kimeswenger, Koller, & Schmeja 2000 for further details).

## 2. MODEL FOR V605 AQL AND RESULTS

The newly developed numerical code NILFISC (Koller 2000; Koller & Kimeswenger 2001a,b) calculating dust temperatures including temperature fluctuations (Guhathakurta & Draine 1989) of small grains, make a detailed model of V605 Aql feasible. Temperature fluctuations occur in dust grains under the following conditions: The dust grain is small and has a low heat capacity, the ambient radiation field is dilute to give the grain time for cooling down, and the radiation field contains a high-energy, UV photons. If these conditions apply, the infrared emission rises mainly at mid and near infrared wavelengths. Together with the photoionization code Cloudy (Ferland et al. 1998), the emission and absorption of gas and dust can be considered together.

The dust shell model applies a decreasing dust density $\propto 1/r^2$ which is consistent with models for steady outflow at a constant velocity during a short nucleation period. The parameters for the grain

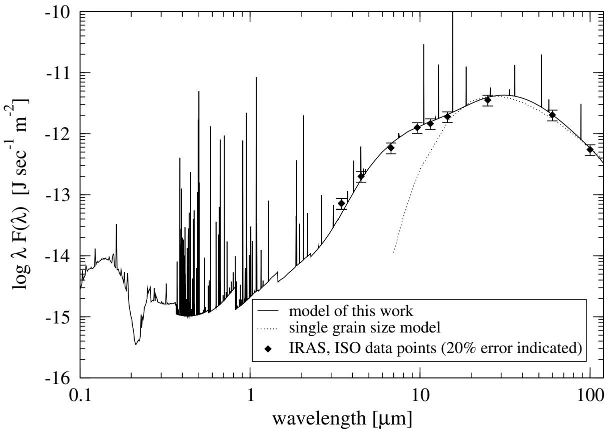


Fig. 1. Model for V605 Aql calculated with temperature fluctuations of dust grains and parameters in Table 1. Diamonds represent ISO observations (Kimeswenger et al. 1998) with a 20% error indicated. The dotted line is the result from a single grain size model (Pollacco et al. 1992). The numerous emission and absorption lines are due to the gaseous component in this model.

size distribution and the inner radius of the dust shell are left as free parameters. The outer radius can be limited to a maximum value of 2″ (Geckeler, Kimeswenger, & Koller 1999). The adopted distance of 5 kpc and the dust shell size is in agreement with velocity determinations by Pollacco et al. (1992).

The introduction of a grain size distribution (Mathis, Rumpl, & Nordsieck 1977) improves the situation significantly compared to the single grain size model (Fig. 1). The total dust mass in our model is higher than evolutionary model computations (Bloecker 1995) currently predict. As Guerrero & Manchado (1996) indicate, the outflow can also be bipolar of which we only see the blueshifted side. Such a bipolar outflow can significantly reduce the required dust mass. However, non-spherical symmetries are not included in the current version but are planned for future versions of our code.

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TABLE 1

MODEL PARAMETERS FOR V605 AQL

| | |
|---|---|
| **Gas shell** | |
| Total gas mass | $7.6 \times 10^{-2} M_{\odot}$ |
| Hydrogen abundance | $10^{-6} \times$ solar |
| **Dust shell** | |
| Inner radius | $r_{\rm in} = 2.5 \times 10^{14}$ m |
| Outer radius | $r_{\rm out} = 3.0 \times 10^{14}$ m |
| Total dust mass | $8.0 \times 10^{-3} M_{\odot}$ |
| Visual extinction | $A_V = 7$ mag |
| **Dust material** | |
| Carbonaceous grains | $p = 3.1$ |
| Size distribution (MRN) | $a_{\rm min} = 6$ Å<br>$a_{\rm max} = 4.55$ $\mu$m |
| **Central star** | |
| Luminosity | $L = 5800 L_{\odot}$ |
| Black body | $T = 100\,000$ K |
| Distance to Abell 58 | $d = 5$ kpc |

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