Active Asteroid belt causes the UXOR phenomenon in RZ Piscium

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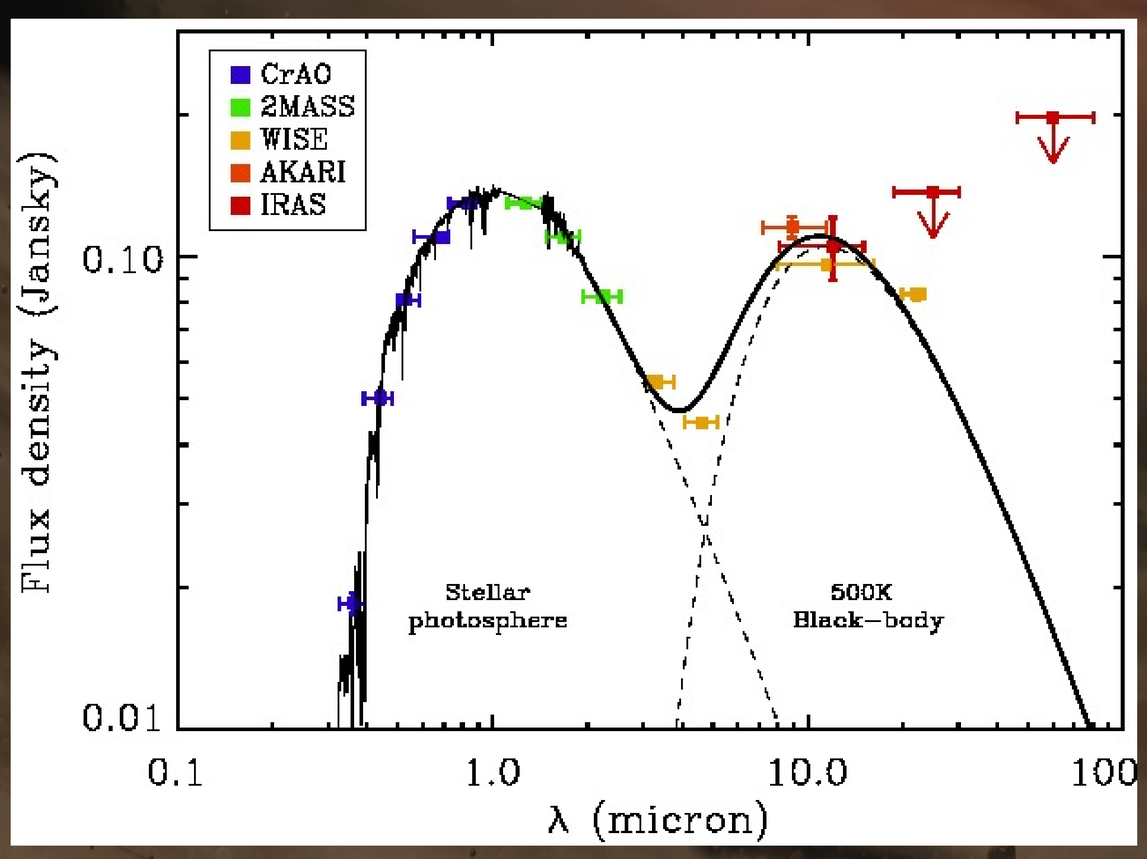
In the course of the formation of a star, an equatorial disk is present, whose purpose evolves from an angular momentum redistributor, which facilitates star growth, to a planet builder. We present one of the strongest infrared excesses of transitional objects observed to date, and we provide a detailed periodicity analysis of the optical variability.

The object: RZ Piscium

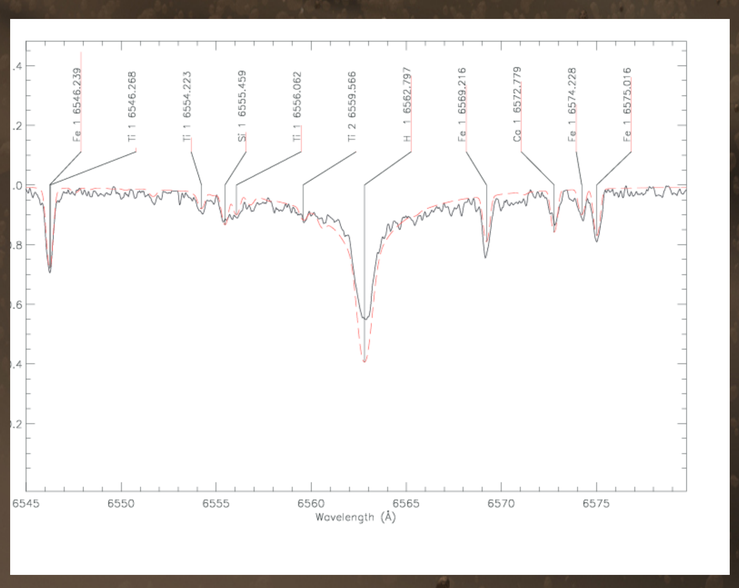
RZ Psc is a solar-type star (K0 IV, Herbig 1960) and well known for its brightness variability with time. The variability has all the hallmarks of the so-called UXOR variability seen among pre-main sequence stars (see section variability intermezzo). RZ Psc sporadically has photometric minima with amplitudes of $\Delta V \approx 2^m - 3^m$ that last from a few days up to a few weeks. During a minimum, it displays bluer optical colours and an increased linear polarization due to an increased contribution by scattered light off small dust grains (e.g. Grinin 1988; Grinin et al. 1991). This type of variability is strictly associated with the occultation of the star by dust in the optically thick accretion disks of stars younger than 10 million years (Dullemond et al. 2003). RZ Psc is estimated to be approximately three times as old (Grinin et al. 2010a,b). Correspondingly, the star does not display the benchmark properties of young stars such as ionized gas transitions (e.g. Fig. 3) or excess emission by hot (1500 K) dust. Rz Psc is therefore **enigmatic** because of a variability that is normally caused only by optically thick accretion disks. In this follow-up study, we report that the object has one of the strongest infrared excesses observed to date, and we provide a detailed periodicity analysis of the optical variability (see photometric variability intermezzo).

Fig.1 A mid–IR excess that is 8% of Lbol.



SED of RZ Psc. A K0 IV model photosphere (Pickles 1998) fits the optical and near–IR measurements shortward of 3mu. Longward of 3mu, the excess emission is markedly dominant and contributes 8% to the total source luminosity. The solid black line corresponds to the total flux of the stellar photosphere plus a single black–body curve of 500K. Some uncertainties in the flux measurements are smaller than the plot–symbol. The errorbars in wavelength indicate the width of the filter, which corresponds to 50% of the transmission. Assuming optically thin dust, the characteristic distance of the dust is 0.4 AU. A cold (100K) dust component cannot be excluded by the current set of measurements, but the total emission at 60mu should be <0.05Jy. If sculpted by a companion, and combined with the absence of any radial velocity variation down to 2 km/s (Shevchenko et al. 1993), the gap can result from a body with a mass of <38 MJup.

Fig.3 But no sign of accretion/activity in Halpha.



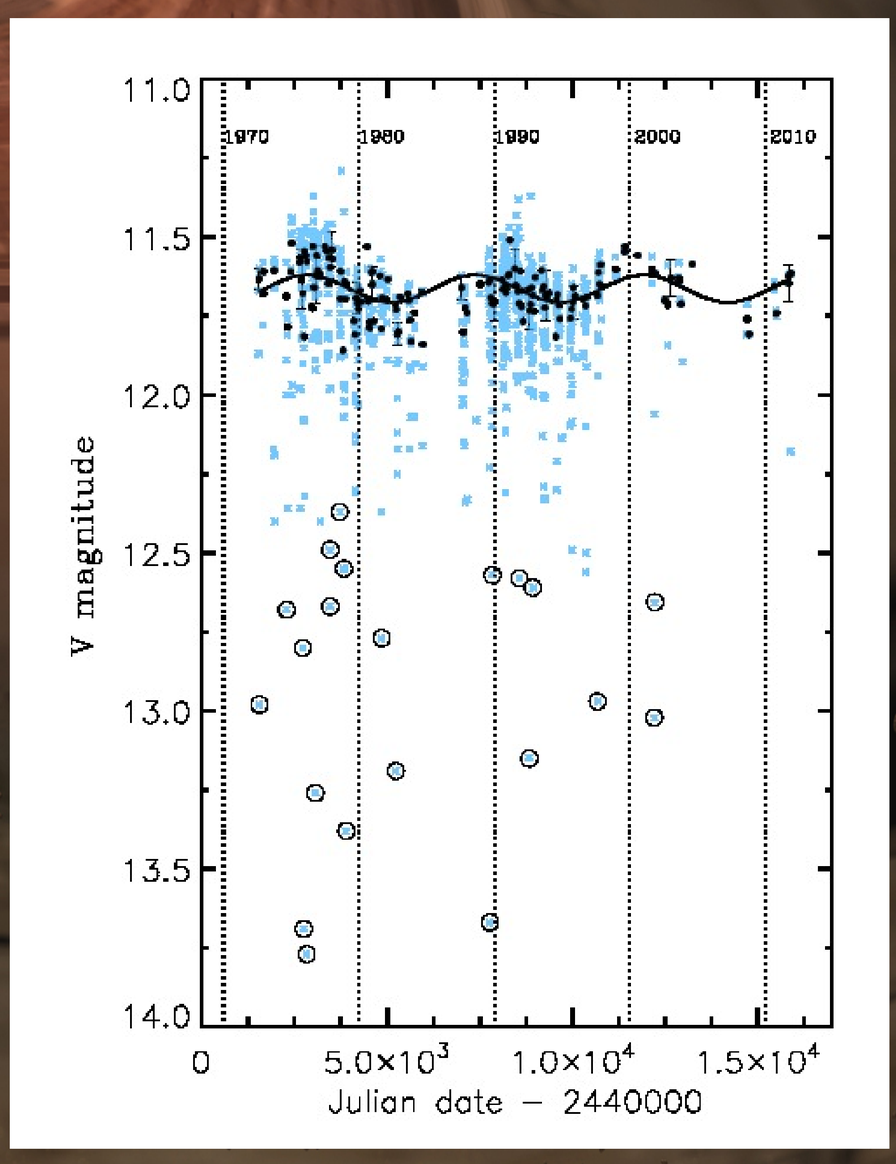
The available age constraints (lithium, kinematic [b ~ 35 degrees]) exceed the characteristic time for optically thick accretion disk. The object's age ranges between 10 and 70Myr. The system is nonetheless considered to be relatively young.

Summary

RZ Psc adds to a growing number of young main–sequence stars with exceptionally strong and warm (500K) IR excess. These excesses are stronger than can be explained by the collisional cascade model, that is applicable to regular debris disks (Melis et al. 2010). Transient events may be involved as indicated by the dust grain properties (Olofsson et al. 2012). For example, collision between two major bodies or a 2nd belt at larger radii feeding the inner dust distribution. Melis et al. (2010) find warm dust near solar–type stars with ages from 30–100 Myr, which could correspond to the maximum in dust excess (24 micron) stars around 40Myr in young stellar clusters (Smith et al. 2011). We propose that the dust occultation events in RZ Psc present a dynamical view of an active asteroid belt whose colliosional products sporadically obscure the central star.

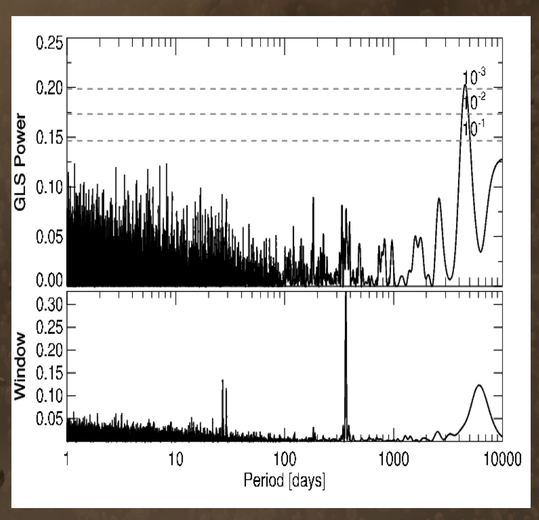
Photometric variability intermezzo

Fig.2 UXOR–type photometric variability with a twist



The optical variability of the star in the past 40 years shows the typical UXOR phenomenon. In particular the light–curve shows two effects: 1. brightness decreases of up to 2.5 visual magnitudes, on average once every year, but the events are aperiodic. The brightness minima last 1 to 2 days. From the rate of flux change, one can estimate the tangential velocity and approximate the distance for an opaque screen (paper I). From this, an orbital distance of 0.6 AU is found. 2: A modulation of the peak flux with a cycle of 12.4 years. We speculate that if this modulation is due to perturbation in the disk induced by co–planar low–mass companion then this component may have an a = 5.3±0.6AU.

A rigorous periodicity analysis was performed, employing averaging per time–bin involving an optimal bin–size search taking into account bin statistics (black points with variance in Fig. 2), selecting measurements that were not affected by UXOR–type obscuration events, computing GLS periodogram. This revealed a period of 12.44yr. Removing of the period from the data results in a powerspectrum without significant power–peaks.



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