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# Prospects of pulsating stars studies with the 4-m ILMT

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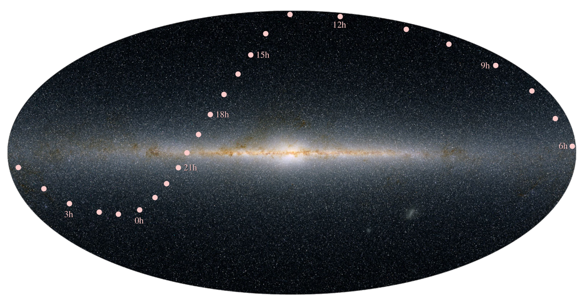
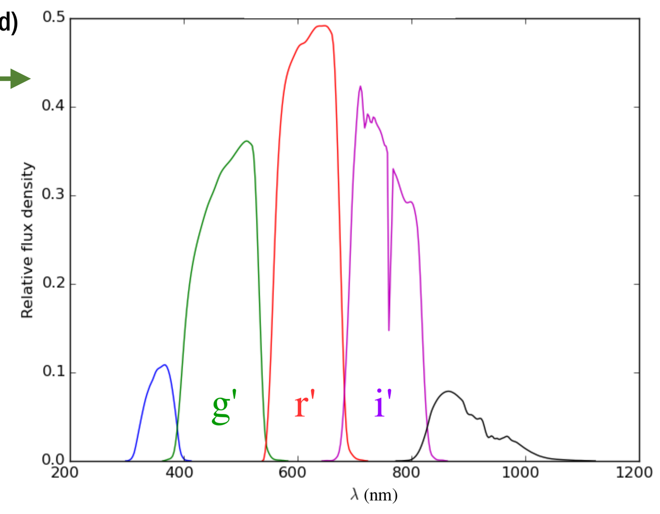
The Hertzsprung-Russell diagram is covered with pulsating stars of many different kinds and flavours. Asteroseismology uses the pulsations of these stars to gain information about their interior, which is needed to improve our understanding of stellar evolution. During the last decade, asteroseismic studies have received an enormous boost thanks to space missions like MOST, CoRoT, Kepler/K2, and TESS. These missions have collected nearly uninterrupted photometric time-series with a precision down to a few micromag and a total time base of up to 4 years. TESS is the only one of these missions that is still collecting data and that is covering the largest part of the sky and hence will have targets in common with the ILMT strip. For which types of pulsating stars are the ILMT observations expected to give an added value to the already existing space-based observations? In this poster, we try to give an answer to this question.

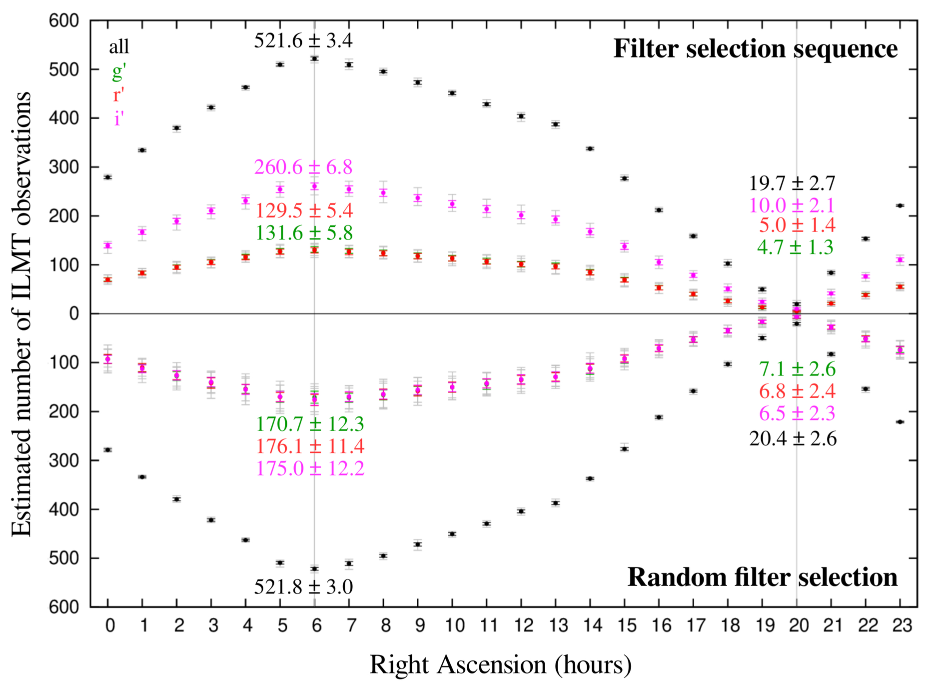
## Assumptions time series

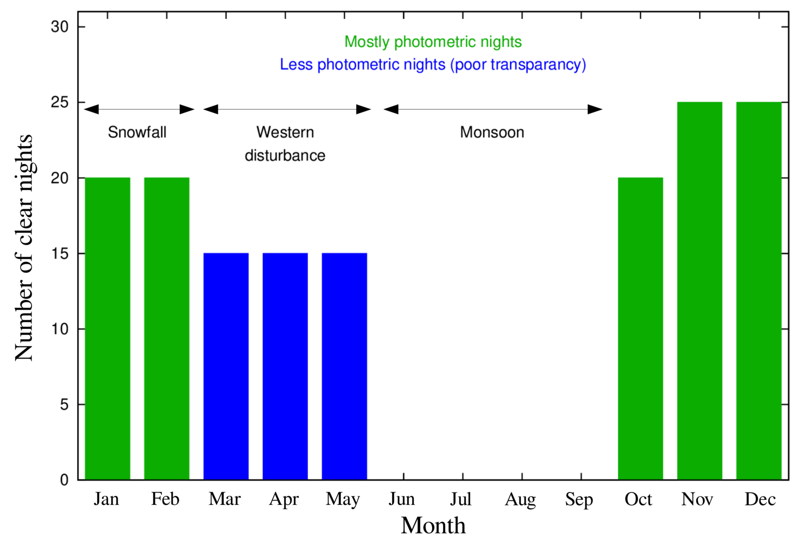
100 simulations

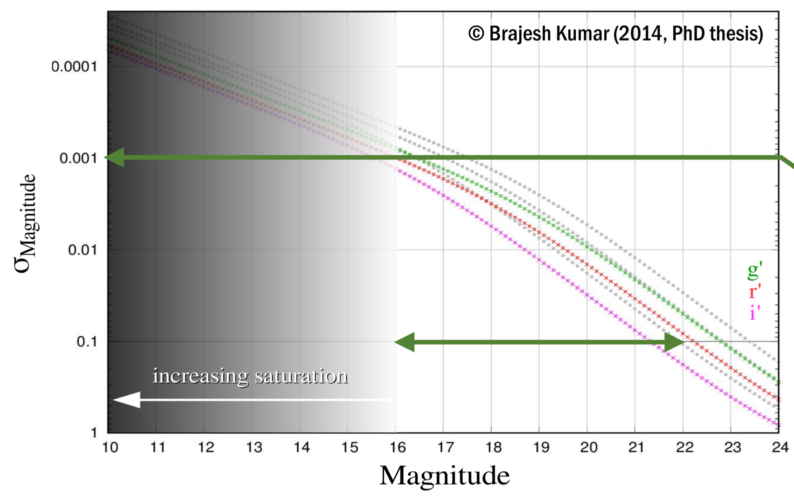
- 5 years of observations
- Targets: declination 29h22m26s ± 13m30s passing through meridian once a night
- Integration time: 102 sec (should be at maximum 5% of pulsation period)
- Filters: g', r', i'
- Observing strategy:
  - Filter selection sequence: i', g', i', r', i', g', i', r',...
  - Randon filter selection
- Weather statistics Devasthal:
  - Random selection of nights within month






## Estimated error in magnitude

For 1 observation: (102 sec in colour)

- Pulsation amplitudes: above 0.001 mag
- Magnitude range: roughly 16 – 22 mag

For 3 observations combined: (306 sec in grey)

- Advantage: gain of 0.5 mag in limiting magnitude
- Disadvantage: loss of cadence in time series

## Period analysis

Detectable periods:

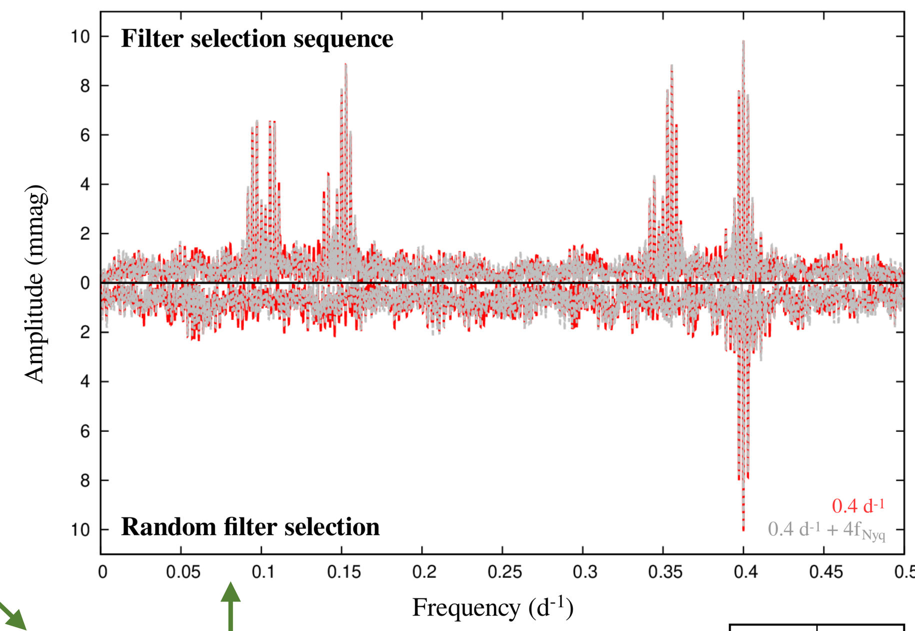
- Longest period: 2T
  with T total timespan of observations
  - ILMT: T = 5 years ⇒ ~10 years
- Shortest period: $1/f_{Nyq} = 2f_s^{-1}$
  with $f_s$ the sampling rate
  - ILMT: $f_s$ = 1 siderial day ⇒ ~2 days

Aliasing:

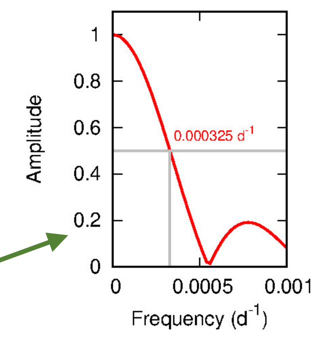
- Strong for filter selection sequence
- Absent for random filter selection
  ⇒ combine with other observatories

Frequency resolution:

- HWHM central peak window function



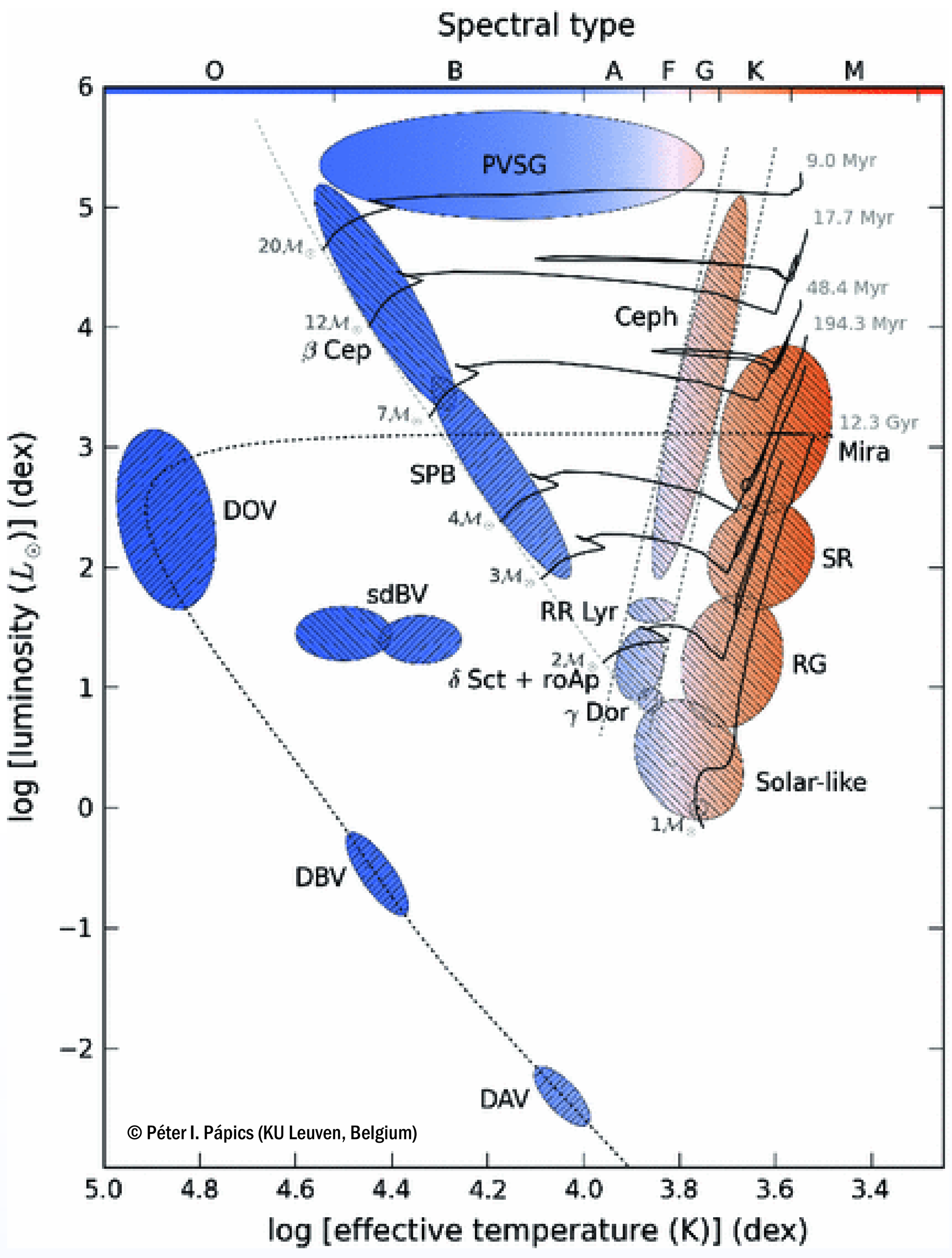

Periodogram up to $f_{Nyq}$ for a simulated ILMT dataset with sinusoidal variations with an amplitude of 10 mmag and a period of 0.4 $d^{-1}$ (red) and 0.4 $d^{-1}$ + $4f_{Nyq}$ (grey). The timestamps are taken from the dataset with the highest number of observations in r' for the filter selection sequence (top) and the random filter selection (bottom).




Central peak of the corresponding window function.

| Pulsation class | Periods | Amplitudes | Brightness |
|---|---|---|---|
| Solar-like oscillators (Solar-like) | order of minutes | < 0.001 mag | |
| d Scuti stars (d Sct) | 1 -5 hours | < 0.9 mag | |
| γ Doradus stars (γ Dor) | 0.3 – 3 days | < 0.03 mag | |
| rapidly oscillating Ap stars (roAp) | 5 – 25 minutes | < 0.02 mag | |
| β Cephei stars (β Cep) | 2 -7 hours | < 0.04 mag | too bright |
| Slowly Pulsating B stars (SPB) | 0.3 – 3 days | < 0.03 mag | too bright |
| Periodically Variable Supergiants (PVSG) | 10 – 100 days | < 0.3 mag | too bright |
| RR Lyrae stars (RR Lyrae) | 0.2 – 1 days | < 1 mag | |
| Cepheids (Cepheids) | 0.1 – 200 days | < 1 mag | |
| Red Giant stars (RG) | 1 hour – 4 days | < 0.001 mag | |
| Mira variables (Mira) | 80 – 1000 days | > 2.5 mag | |
| Semi-Regular variables (SR) | 20 – 2000 days | < 4 mag | |
| sub-dwarf B Variables (sdBV) | 90 seconds – 4 hours | < 0.3 mag | |
| pulsating pre-white dwarfs (DOV) | 5 – 85 minutes | < 0.3 mag | |
| pulsating white dwarfs (DBV/DAV) | 100 – 1500 seconds | < 0.4 mag | |
| Requirements | > 0.5 hours<br>2 days – 10 years | > 0.001 mag | roughly<br>16 - 22 mag |

*(Background image: One of the first images from the ILMT, consisting of an overlay of three individual observations in three different colours of a small portion of the sky containing the galaxy NGC 4274 as seen in the upper right corner)*




## Pulsating stars

Hertzsprung-Russell diagram is covered with many different classes of pulsating stars (ellipses on the figure).

Each pulsation class has a typical:

- Range of pulsation periods (given in column "Periods" of the table)
- Range of pulsation amplitudes (maximum or minimum observed amplitude given in column "Amplitudes" of the table)

The table indicates the prospects to study them based on time series of single ILMT observations with standard techniques with respect to requirements on pulsation periods, pulsation amplitudes and brightness:

- White: no problems
- Light gray: some difficulties
- Dark gray: not possible

## Conclusions

The prospects are best:

- For pulsating stars with
  - Right ascension close to 6 hours
  - High enough magnitude (roughly 16 – 22 mag)
  - Long pulsation periods
    - Limit from integration time ⇒ longer than 0.5 hours
    - Limits from period analysis ⇒ 2 days – 10 years
  - Pulsation amplitudes above 0.001 mag
- For random selection of the filter (g', r' or i')
- If observations can be combined with other observatories

Semi-regular variables
Mira variables
Cepheids

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