Sonification of Transient Lightcurves: Supernovae Case Studies

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Quick Summary

- Development of flexible data sonification python package
- Linear and plateau supernovae can be audibly differented
- New method for inclusive citizen science lightcurve classification

In a first for citizen science astronomy, TransientZoo moves beyond visual analyses by sonifying lightcurve data, producing audio files that depict variations in magnitude as changes in pitch.

Introduction

Understanding pitch

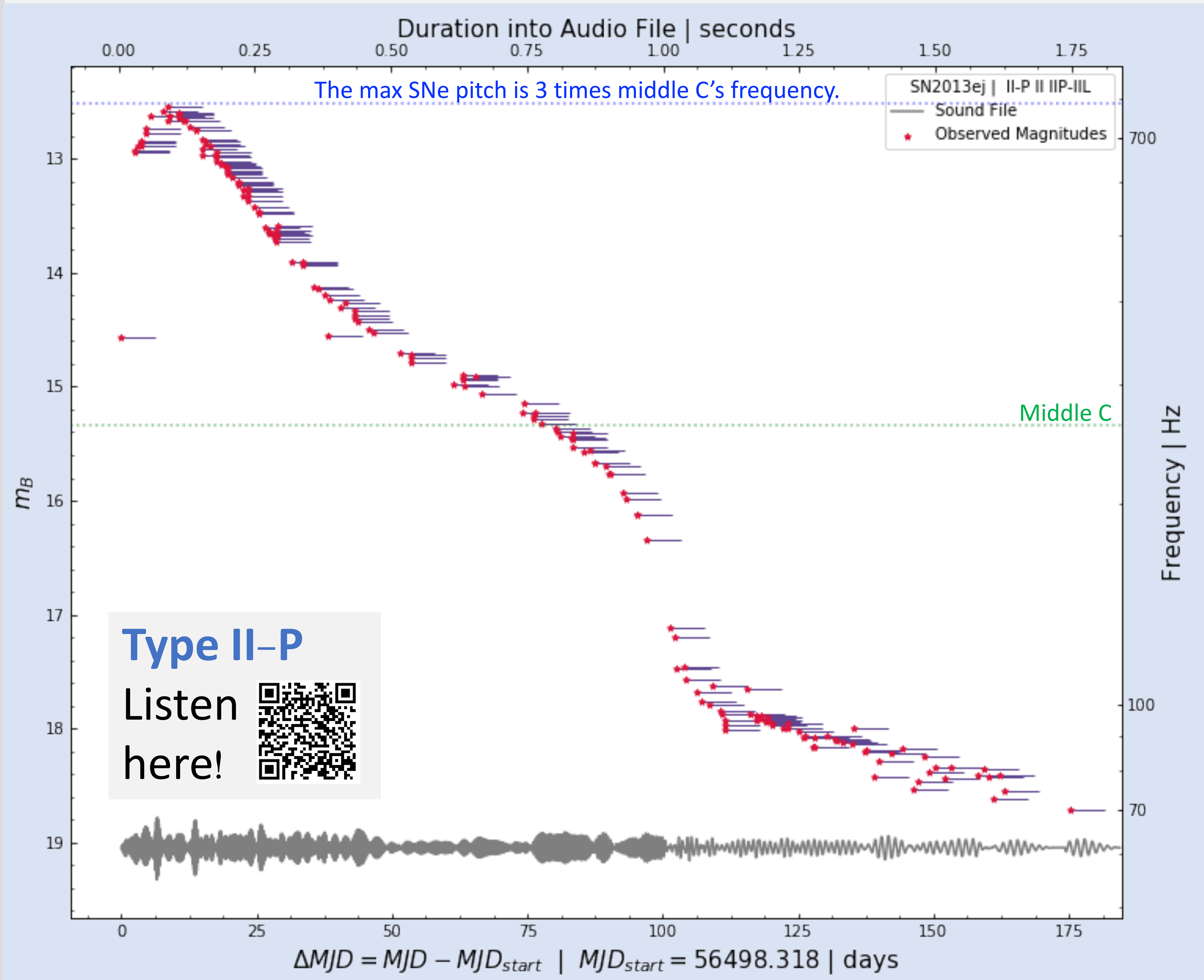
The cent is a logarithmic unit of measure for pitch intervals where n ≈ 3986log(b/a) defines the number of cents between the pitch frequencies a and b.

Human Pitch Sensitivity

The average person is capable of discerning independent subsequent pitches with a difference of ~10 cents (Kollmeier et al. 2008). The human ear is most sensitive to frequencies between ~500-4000 Hz, similar to the range of a standard piano.

With these parameters, lightcurves can be translated into audio files that map magnitudes to specific pitch frequencies, with a $\Delta m = 0.02$ mag corresponding to a 10 cent pitch difference.

Our Sonification Technique



Each data point corresponds to a short tone in the sound file.

Observation time determines the placement of the tone in time.

The magnitude determines the tone's pitch.

As magnitude increases and brightness lowers, the tone's pitch gets lower.

A Case for Sonification

Why sonify lightcurves?

- Thanks to the nature of human hearing, we can audibly discern pitch differences of 10 cents (corresponding to 0.02 mags). At this scale we can "hear" lightcurves that span up to 7 magnitudes.
- The simultaneous depth and range of pitch sonification is superior to methods using changes in decibels, or "loudness."
- This approach opens up citizen science to participants who are visually impaired.

But why our method?

Our method is tailored to the capabilities of the human ear and audio equipment. It is flexible, applies to a broad variety of data inputs, is fast to generate, and offers a unique means of classifying time-domain data.

The Code

Frequency

Frequency is set by one of the following:

- **simple case:** a frequency max and min
- **nuanced case**: a frequency max and a cents / value scale

```
# frequencies
C4 = 261.6  # Hz
frequency_args = {
    'frequency_max': C4 * 3,
    # 'frequency_min': C4, #* (1 / 2),
}
```

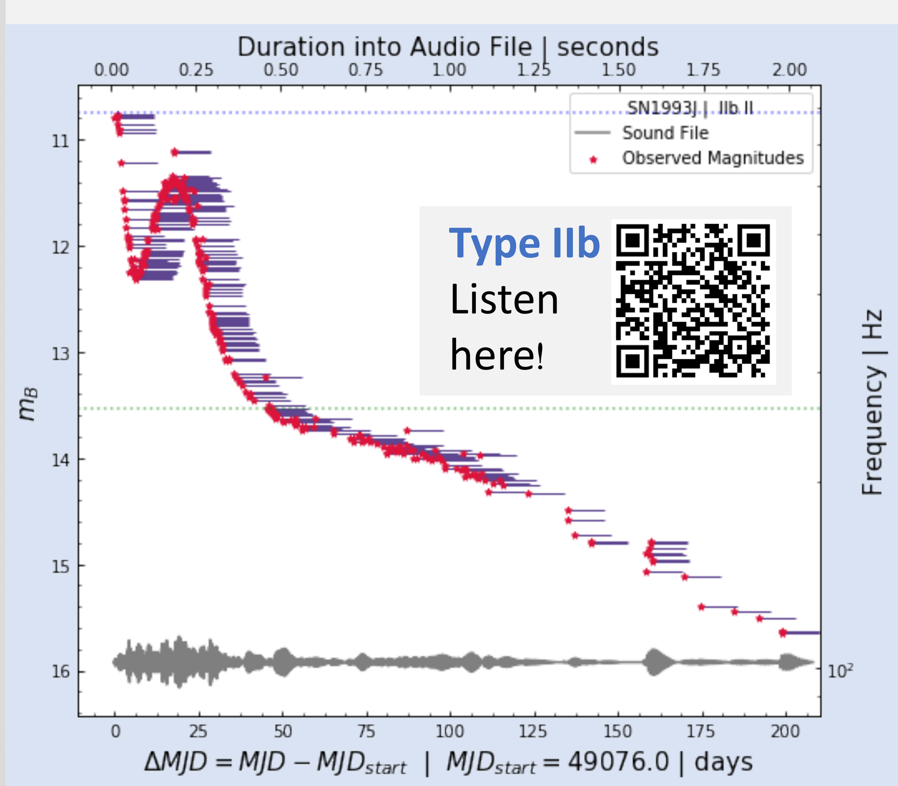
Duration

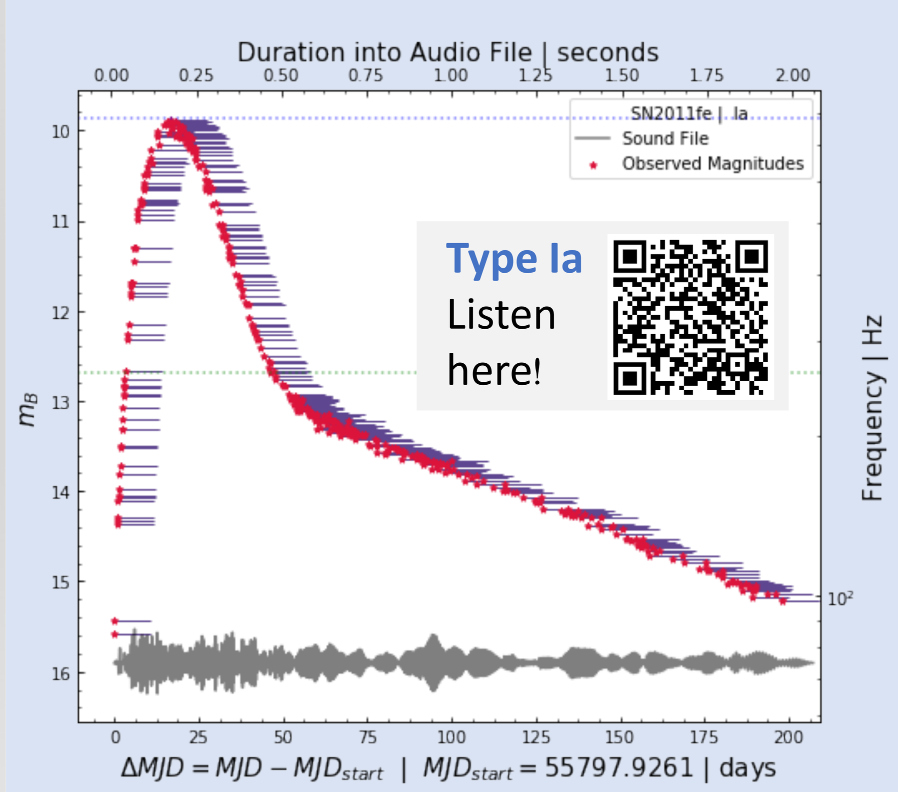
Duration is set by a total time, a duration scale, or by choosing the length of minimum or maximum time difference.

```
Tone = SonifyTool(values, times,
                  frequency_args=frequency_args,
                  duration_args=duration_args,
                  length=.1) #ms
```

Code will be released on github with publication.

SN Case Studies





At the left are two examples of successfully sonified audio light curves, for a Type IIb (top) and Type Ia (bottom) supernova.

We find that linear and plateau supernova light curves can be audibly differentiated.

This approach offers a new tool for citizen science lightcurve classification.

Future Work

Citizen Science

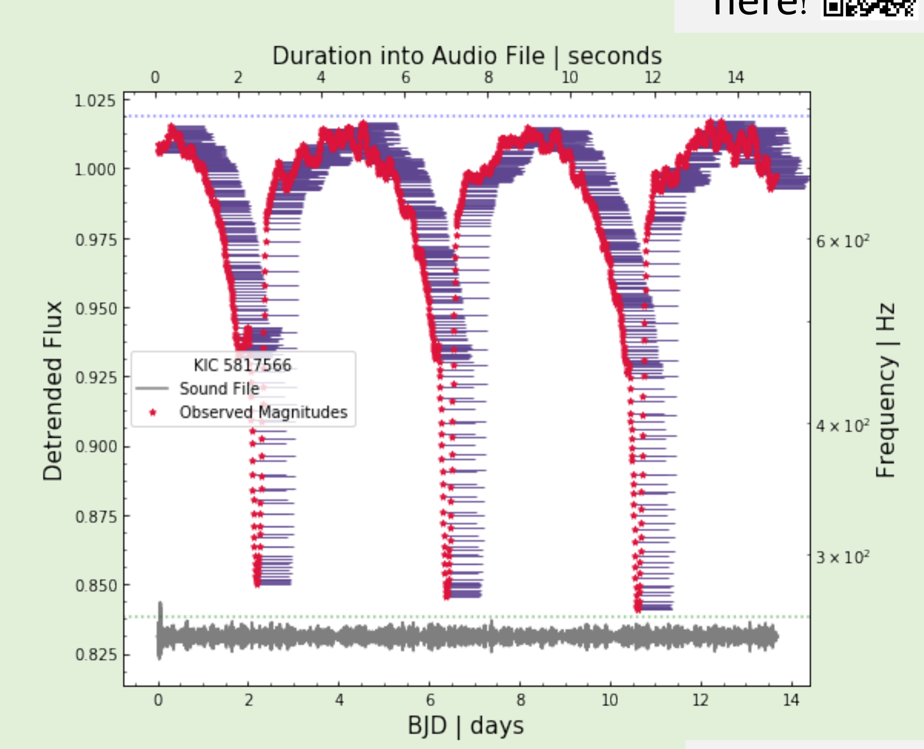
We're building TransientZoo, a citizen science program that will allow participants, including the visually impaired, to classify supernova lightcurves using sound.

Other Variables

We've also explored the sonification of other time-domain data, which will eventually help TransientZoo expand into LightcurveZoo. To the right are pictured examples of an eclipsing binary from Kepler's catalogue and an RR Lyrae from our observations. LightcurveZoo will ultimately include a collection of transients: supernovae, binaries, and variable stars.

Eclipsing Binary

Listen here!



RR Lyrae

Listen here!