Computationally efficient search for CW sources

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- Based upon the **Arithmetic Fourier Transform** (no multiplications!)
- **Exploratory project** - to find an efficient parallel realization of the method

The Challenge

- Search for CW sources of unknown frequency and location (Doppler)
- Apply matched filter to months (or years) of collected data
- Find the most efficient means of applying many matched filters to the data.

Arithmetic Fourier Transform (AFT)

Tufts, 1989

Mobius function:

- $\mu_1(1) = 1$,
- $\mu_1(n) = (-1)^s$ if $n=(p_1)(p_2)(p_3)..(p_S)$, where p_i are distinct primes,
- $\mu_1(n) = 0$ if $p^2|n$ for any prime p.

Fourier series coefficients of a zero-mean signal A(t), band-limited to N harmonics, periodic within the unit interval:

$$S(n,t_{ref}) = \frac{1}{n}\sum_{j=0}^{n-1} A(t_{ref} - \frac{j}{n}) \qquad \text{for} \quad n = 1,2,3,.....N$$

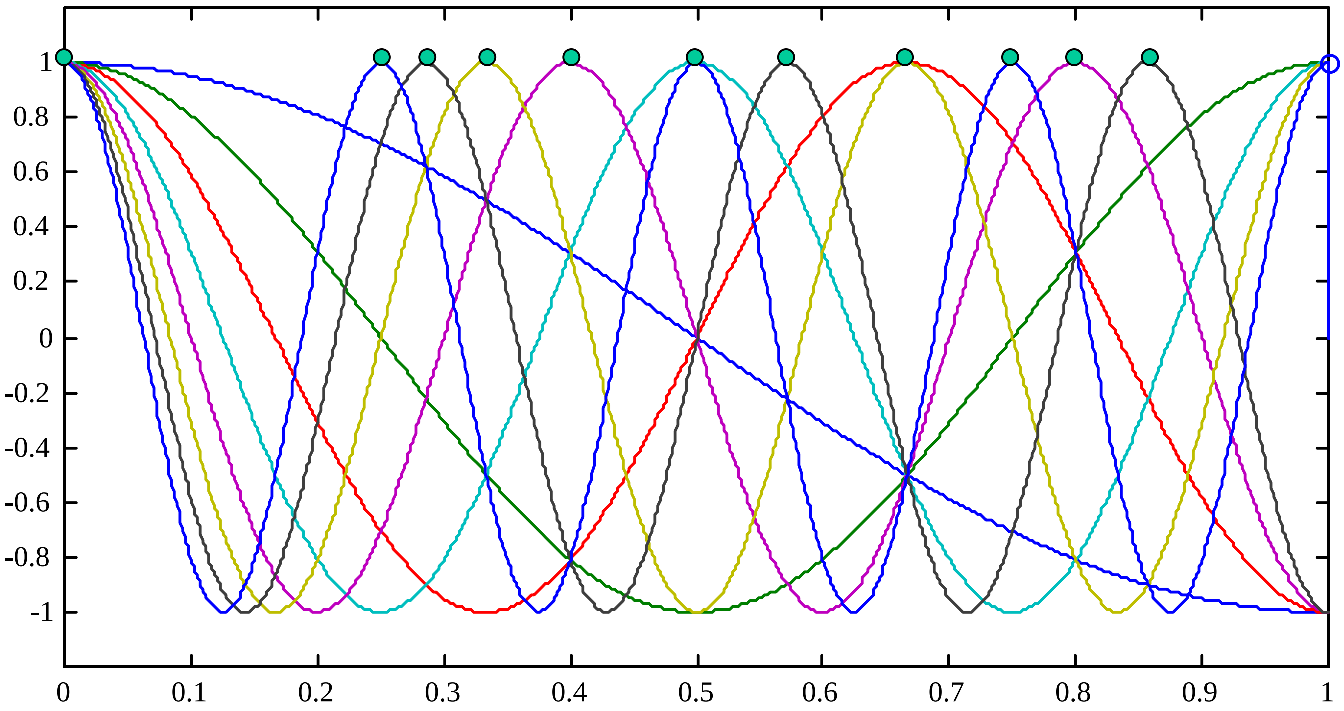
$$a_k(t_{ref}) = \sum_{m=1}^{\infty} \mu_1(m) \cdot S(mk,t_{ref}) \qquad \text{for} \quad k = 1,2,3,.....,N$$

Extension of AFT method to matched filtering

- DFT is like matched filtering with sine, cosine basis functions
- Extend method to more general matched filters
- Each filter implies a unique re-sampling of the data
- Apply hundreds or thousands of AFT style matched filters in parallel

Non-uniform sampling for AFT

Sample at peaks of basis functions



Implementation

- Computation comes down to re-sampling and summing of data samples
- Zero order interpolation - what is the error?
- Other interpolation methods (analog?)
- Hardware realization - many simple computations in parallel
  - **Cluster of simple computers?**
  - **Programmable gate arrays?**
  - **Custom ASIC?**