

In this post I will show you how to calculate and plot the Chebyshev Polynomials of the second kind using a C Program and Gnuplot.

We will be using the following information:

$$U_0(x) = 1$$

$$U_1(x) = 2x$$

and the recurrence relation:

$$U_{n+1}(x) = 2xU_n(x) - U_{n-1}(x) \text{ where, } n \text{ starts from } 1.$$

Modifying the recurrence relation a little, so that n starts from 2, we get:

$$U_n(x) = 2xU_{n-1}(x) - U_{n-2}(x)$$

We will create a program that calculates the values of the Chebyshev Polynomials at various x values and for different n and store these values in a txt file. Then just plot it using Gnuplot.

We will create two functions called 'U0' and 'U1', that contain the definition of respectively.

Then we will create a function 'Un' that will use the first two functions and recursion to find the value of Chebyshev Polynomials for different x,n.

PROGRAM:

```

/*****
*****Chebyshev Polynomials*****
*****/
#include<stdio.h>
double U0(double x){
    return 1;
}
double U1(double x){
    return 2*x;
}
//General form of Chebyshev polynomial of second for a given value of n and x
double Un(double x, int n){
    if(n==0){
        return U0(x);
    }
    else if(n==1){
        return U1(x);
    }
    else{
        //using the recurrence relation
        return 2*x*Un(x,n-1)-Un(x,n-2);
    }
}
main(){
    double x;
    FILE *fp=NULL;
    fp=fopen("cheby.txt","w");
    //Write down the values to a file
    for(x=-1;x<=1;x=x+0.01){
        fprintf(fp,"%lf\t%lf\t%lf\t%lf\t%lf\t%lf\n",x,Un(x,0),Un(x,1),Un(x,2),Un(x,3),Un(x,4));
    }
}

```

When you run the above C, it will generate a file called 'cheby.txt' which would contain 6 columns of data-points.

The first column contains the 'x' values and the rest of them are for $U_0(x)$, $U_1(x)$, $U_2(x)$...

These can be easily plotted using Gnuplot by using the following commands:

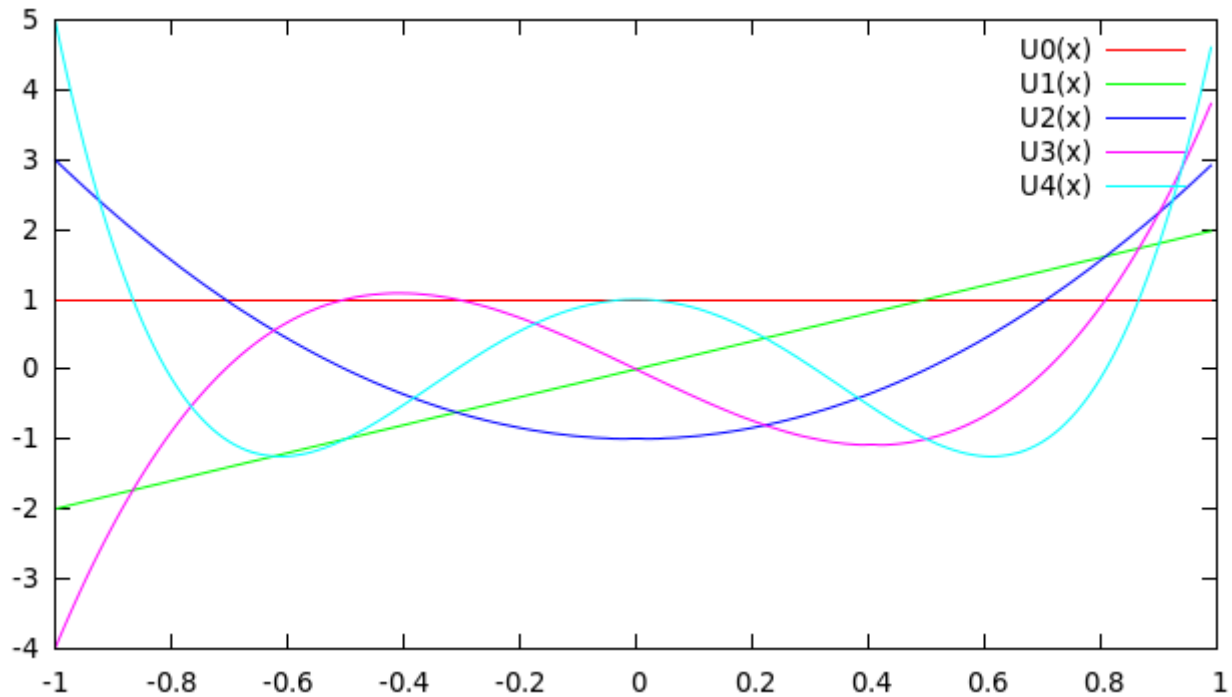
GnuPlot Command:

```

->set xlabel 'x'
->plot 'cheby.txt' u 1:2 w l t "U0(x)", '' u 1:3 w l t "U1(x)", '' u 1:4 w l t "U2(x)", '' u 1:5
w l t "U3(x)", '' u 1:6 w l t "U4(x)"

```

OUTPUT(Gnuplot):



References:

https://en.wikipedia.org/wiki/Chebyshev_polynomials

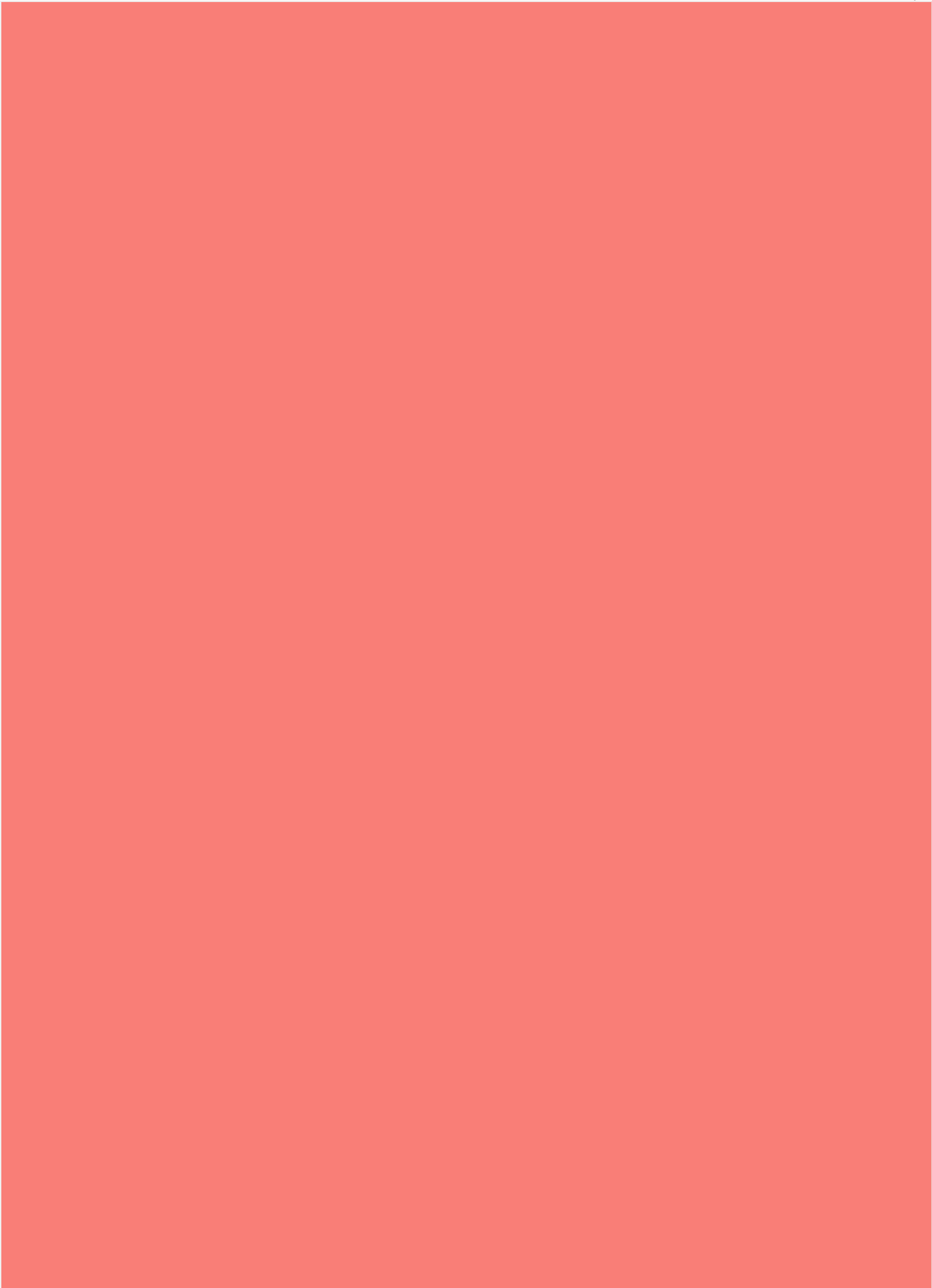
<http://mathworld.wolfram.com/ChebyshevPolynomialoftheSecondKind.html>



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I'm a physicist specializing in computational material science with a PhD in Physics from Friedrich-Schiller University Jena, Germany. I write efficient codes for simulating light-matter interactions at atomic scales. I like to develop Physics, DFT, and Machine Learning related apps and software from time to time. Can code in most of the popular languages. I like to share my knowledge in Physics and applications using this Blog and a YouTube channel.

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