MATH 110: Mathematics and Music
CD #4: Composing with Numbers: Bells, Rows and Magic Squares

This CD might challenge your concept of "music." Here we feature some examples of change ringing from some of England's most famous churches. We also include some more modern "mathematical music" from the 20th century, featuring the twelve-tone method of Schoenberg, the purely mathematical creations of Xenakis and the use of magic squares by Davies.

As discussed in CD #2, a rather radical shift occurs at the start of the 20th century, when many composers discarded tonality altogether seeking more freedom and flexibility in utilizing all the notes of the chromatic scale, rather than favoring one over the others. Schoenberg writes "Tonality is not an eternal law of music, but simply a means toward the achievement of musical form." Despite this assessment, it is interesting to note that Schoenberg still utilizes the same musical ideas as Bach (inversion, retrograde, transposition) to build his music out of a given tone row. Xenakis took the atonality concept even further, composing "sound blocks" based on some very precise mathematical calculations involving probability theory. Finally, Davies uses the magic square of the sun to serve as an architectural blueprint for his interesting composition depicting the remarkable properties of light.

What to listen for: Portions of the music for the last three pieces on this CD were distributed in class, although this is hardly the type of music you "follow along with" as you listen. Concentrate as you listen to each piece (don't give up), trying to discern the composers intent. What emotions and energy do you think the composer is depicting? What strikes you as creative or interesting about the use of instrumentation? How does the mathematics influence the creative process?

1. *Little Bob Maximus*, St. Mary Redcliffe, Bristol, England. A recording of the first 176 changes from Little Bob Maximus, this is Track 1 off of a SayDisc Records CD entitled Church Bells of England. The church of St. Mary Redcliffe was described by Queen Elizabeth 1st as "the faerest and goodliest parish church in all my realm". Many of the bells were cast in 1903 with numbers 8 and 10 dating to 1763 and number 11 all the way back to 1622. A "Flat" Sixth bell was added in 1951 while a "Sharp" Treble rounded out the collection in 1970. Notice that the excerpt starts on rounds (moving in pitch from highest to lowest) but after about a minute, enough permutations have occurred that the pitch moves in completely the opposite direction (from lowest to highest).

2. *Grandshire Doubles*, St. Bartholomew the Great, Smithfield, England. This is track 11 off the previous CD. St. Barthlolomew's church in London was founded in 1123 as an Augustinian Priory. The five bells heard here were cast by Thomas Bullisdon of Aldgate in about 1510 and are the only complete medieval set of more than four from one creator in England. This recording is of the usual band of Sunday bell ringers at the church. Due to the fact that there are only five bells, it is easier to follow the different changes as they progress through the piece.

3. Arnold Schoenberg, *Suite for Piano, Minuett: Moderato - Trio* Op. 25, 1925. Track 20 on a Deutsche Grammophon CD entitled Schoenberg: The Piano Music performed by Maurizio Pollini. This is Schoenberg's second piece composed for piano during his twelve-tone period. The entire work (not just this movement) is based on the same 12 note tone row (discussed in class on April 16th). The music for the Trio, which begins about 1:53 into the recording, was distributed in class on April 16th (see p. 130 of the course text). The opening of the Trio is easily distinguished by its rhythmic punctuations alternating between each hand. The piece is atonal in the sense that

there is no central key or tonic around which the music is based. In the Trio Schoenberg uses only the six tone rows P-0, P-6, I-0, I-6, R-6 and RI-6 (see the labels on the music in the text). The number six is significant in that 6 half-steps equals half the octave (the tritone interval) and the tone row begins and ends a tritone apart. Each of the transformations above (transposition, inversion, retrograde and retrograde-inversion) all consequently begin and end on either E or B♭, making the music flow easier from one row to another.

4. Iannis Xenakis, *Pithoprakta*, 1955 - 1956. Track 4 from a Le Chant Du Monde CD entitled Xenakis: Eonta, Metastasis, Pithoprakta featuring the Orchestre National de l'O.R.T.F. under the direction of Maurice Le Roux. A small portion of this music along with the mathematical calculations used to create it were distributed in class on April 18th. The piece was dedicated to Hermann Scherchen who conducted its premiere in March 1957 in Munich. This innovative work is written for 46 strings (remarkably all playing different parts), 2 trombones, 1 xylophone and 1 wood block. The composers aim was to use probability theory to determine what notes should follow each other and what lengths they should be played, so-called "Stochastic Music," invented by Xenakis. The piece explores the conflict between continuity and discontinuity by juxtaposing continuous sounds (glissandi in the strings and trombones) with discontinuous ones (pizzicati plucking in the strings, tapping the wood of the strings with the opposite side of the bow, and the sharp, piercing sounds of the wood block.) Xenakis determines the "speed" of a given glissando (the slope found as the ratio of pitch to duration) by using a uniform distribution (sometimes called a normal or Gaussian distribution.) This has the mathematical effect of distributing the speeds equally among all players so that all pitches are freely distributed along a continuous frequency spectrum. In this way, Xenakis extends Schoenberg's main goal in 12-tone music of not favoring any one pitch (in this case frequency) over any other. Given Xenakis' experiences with the Greek Resistance and WWII, it is fairly obvious that this work is the composers musical reflection upon the most tragic of human conflicts – war.

5. Peter Maxwell Davies, *A Mirror of Whitening Light*, 1977. This live recording of the Manson Ensemble, conducted by Diego Masson, was downloaded off of the composer's website MaxOpus (Sir Davies is widely known as "Max"). The title of the piece refers to the alchemical process of purification or "whitening" of a base metal into gold. In his composer's note (distributed in class on April 20th), Davies describes how the light outside his window workplace in Orkney gave him inspiration for the piece. Davies uses an 8×8 magic square to create the entire set of notes and durations for the piece. Each number in the square corresponds to a particular note from an 8-note plainchant *Veni sancte spiritus* or its transposed version. (The original was transposed to start on one of the eight notes of the chant, thus creating a total of eight 8-note phrases.) The magic square and some excerpts detailing its usage were distributed in class on April 20th (see pp.141 - 143 of the course text). Concerning the rigidity of the magic square, Davies writes "And so when I really wanted to be wild towards the climax of this work, I imposed very rigid rhythmic and tonal controls derived from the plainsong, and from that magic square; and the result is really quite extraordinary I find, even now."