March 27, 2006

Review of "Study of Physical Characteristics of Meteor Showers Based on Ondřejov Radar Observations", doctoral thesis by D. Pecinová.

**New scientific results**

The work done relating simulations of range activity plots to single station radar observations of meteor showers is impressive. The quantities being found (including shower mass distributions, shower flux, ionization coefficient, self-similarity parameter, and the product of the shape-density coefficient and ablation coefficient are of great interest in studying the parent bodies of streams and the evolution of the streams themselves. It is regrettable that interferometer data were not available for the observations, to remove some of the uncertainty due to sporadic contamination and to add further constraints to the quantities being determined.

It is puzzling that the mass distribution indices of these showers are, in many cases, very low. It would be interesting to compare intensified video observations of the same showers (taken at the same time as radar data, from the same location) which cover the same mass range, to confirm that the low indices are not an artifact of the fitting procedure. The comparisons with visual data and other radar observations are interesting, but simultaneous video data would provide a much more robust check on this parameter.

The fact that the self-similarity parameter parallels so closely the expected strength of the shower meteoroids in each case, on the other hand, is very intriguing. The ionization coefficient is also of great interest, as a combination of theoretical and laboratory studies have not, to date, provided a satisfactory estimate of this parameter at the full range of meteor speeds. After further testing, this technique may provide the basis for a new theory of ionization in meteor trains, which is needed for accurate meteoroid flux calculations based on radar counts, and proper speed distributions.

The technique described here should allow researchers with single station radars, lacking interferometers, to contribute valuable data on major showers.

**Form of the thesis**

The thesis is laid out clearly, and all derivations used in the analysis are clearly laid out. There has been a satisfactory review of literature in this area, covering the relevant research in meteor ablation theory and radar reflection theory. The chapters divide the material in a logical manner. The English could use polishing, though it is quite readable with the exception of one or two sentences.

**Summary**

While the data behind the thesis covers a significant range in time, it is somewhat limited. The thesis represents an impressive effort to relate theory to these limited observations, apparently extracting a great deal of detail from the limits of the dataset. The author seems very capable in matching theory and observation, and seems well suited to creative scientific work. I recommend that the candidate be granted a Ph.D. after a successful defense of this work.

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## Detailed report

**Questions to the candidate:**

Why were the data divided into 20 or 25 km intervals, then interpolated? How much noise was there if the data were divided into 5 km intervals to start with?

How exactly was sporadic contamination removed? For example, which days around each shower were used? The sporadic background varies in intensity and directionality over, sometimes, short periods of time. It would be useful to give dates used in the background calculation.

Was Faraday rotation taken into account for the daytime showers? Most radars suffer some significant attenuation from the daytime ionosphere.

Has the author considered obtaining data for the daytime Arietid shower? This prolific shower seems to have a different origin than the two daytime showers listed. The two daytime showers studied here have parameters which are quite different from the night time showers: a third daytime shower might help to distinguish daytime observing effects, or to rule out their importance.

**Details (mainly a selection of minor grammatical points):**
Chapter 1: Introduction
Page 6, paragraph 1, line 8: "several tens kilometers" should be "several tens of kilometers"
Page 6, paragraph 1, line 8: "After the photography was sufficiently developed, it became the method capable of yielding data...": "Once photography was sufficiently developed, there was a method capable of yielding data..."
Page 6, paragraph 1, line 10: "to drag force": "to a drag force"
Page 6, paragraph 1, line 11: "at each points": "at each point"
Page 6, paragraph 1, line 12: "of meteor event are the most precise from all that are being in use at present.": "of meteor events are the most precise of all those in use at present."
Page 6, paragraph 1, line 13: "individual event": "individual events"
Page 6, paragraph 2, line 5: "it can be used during a day when a photography cannot be used at all.": "it can be used during the day, when photography cannot be used at all."
Page 6, paragraph 2, line 11: "This wavelength span is given": "This wavelength span is limited"
Page 7, paragraph 2, line 8: "the method like this that": "such a method, which"
Page 7, paragraph 2, line 10: "Among others, we have at our disposal range": "Among other measured parameters, we have the range"
Page 7, paragraph 2, line 19: "We have developed the model reflecting all these facts and we have managed to applied it to": We have developed a model reflecting all these facts and have applied it to"

Chapter 2: Simple physical theory
Page 9, paragraph 1, line 6: "underlying the ground of the theory of meteors": "underlying the theory of meteors"

Page 10, case 1., paragraph 1, line 3: "conclusion that from the most severe deceleration suffer meteoroids having low velocity of 15 km s-1": "conclusion that the most severe deceleration is suffered by meteoroids with low velocities like 15 km s-1"

Note that quotation marks will come out correctly using `` instead of ", for the first quote.

Page 12, paragraph 2 (under figure 2.4), line 1: "Evidently, the greater mass of a meteoroid the less progressive change of velocity.": "Evidently, the greater the mass of a meteoroid, the lower its progressive change in velocity."
Page 12, second to last line: "This expression could further be simplified when the argument of the exponential were small enough": "This expression can by simplified further when the argument of the exponential is small enough"
Page 13, paragraph 2, line 1: "Let us put once again stress on the fact": "Let us once again stress the fact"
Page 14, paragraph 2, line 5: "After taking derivation of": "After taking the derivative of"
Page 14, Section 6, line 2/3: "It is height at which the meteoroid's body is heated up enough to get started the process of ablation": "This is the height at which the meteoroid is sufficiently heated to begin the process of ablation."
Page 15, paragraph 3, line 2: "This statement we will now prove.": "We will now prove this statement."
Page 17, paragraph 1, line 4/5: "Let's take a notice of function": "Notice the function"
Page 17, last paragraph, line 3: "Although it is possible to use whatever ionization theory": "Although it is possible to use any ionization theory"
Page 18, Section 1, paragraph 1, line 4: "put the result zero": "set the result equal to zero"

Chapter 3: Radar echo theory
Page 23, paragraph 1, line 2: "a ionized electrically conducted path": "an ionized, electrically conductive path"
Page 24, section 3.2, paragraph 1, line 2/3: "the sufficiently longer stage of balancing of concentrations goes after.": "the longer stage of balancing concentrations follows."
Page 25, paragraph 1, line 2: "the transversal dimension": "the transverse dimension"
Page 25, 1st line after Equation 3.10: "The relation (3.10) means the fact that": "The relation 3.10 means that"
Page 25, 2nd line after Equation 3.10: "and for this purpose": "and for this reason"
Page 25, last line: "When ion collide with electron, they have non-zero": "When an ion collides with an electron, there is a non-zero"
Page 26, lines 6/7 after equation 3.15: "Hence, in order the recombination could play a significant role the ae should be greater more than 10^4 times in comparison with its present value.": "Hence, in order for the recombination to play a significant role ae should be more than 10^4 times greater than its actual value."
Page 26, line 7 after 3.17: "Attachment may assert oneself": "Attachment may assert itself"
Page 26, line 9 after 3.17: "meteoroid's surface, happens rather than to oxygen.": "meteoroid's surface, rather than to oxygen."
Page 27, line 1: "Both last mentioned effects": "Both of the last effects mentioned"
Page 27, last two lines: "only in the case we can neglect the other affects except the ambipolar diffusion the electron line density ae remains constant.": "only in the case

where we can neglect all effects except ambipolar diffusion does the electron line density ae remain constant."
Page 28, paragraph 1, lines 1/2: "the division of meteor trains from point of radar view can be perform due to sign of permitivity e.": "meteor trains can be divided, from the radar point of view, by the sign of the permittivity e."
Page 28, paragraph 2, line 1: "diving line": "dividing line"
Page 28, paragraph 2, line 7: "affirmative": "positive"
Page 29, paragraph 1, line 5: "the transitive ones": "the transition echoes"
Page 29, paragraph 1, line 5/6: "They stretch over the rather large area, which corresponds to the span of ae roughly about four orders." "They stretch over a rather large range, corresponding to four orders of magnitude in ae."
Page 30, 1st line after (3.30): "Let us assume the most important": "Let us include the most important"

Chapter 4: Radar observations
Page 33, paragraph 1, line 3: "monitoring of a different kind": "monitoring with different methods"
Page 33, paragraph 2, line 2/3: "Mass m0 is an optional constant selected in accordance with the kind of data.": "The mass m0 is a constant which depends on the limits of the data."
Page 33, paragraph 3, line 4: "is bounded up with two another terms.": "is bound up with two other terms."
Page 34, second bullet point: "OB affirmatively in clockwise sense": "OB with positive in the clockwise direction"
Page 35, paragraph 2, line 1/2: "a ionized electrically conducted path": "an ionized, electrically conducting path"
Page 35, section 4.2, line 5: "serves us to get an idea about size of that equipment.": "serves to give an idea of the size of the radar."
Page 36, paragraph 1, line 1: "in distance of": "at a distance of"
Page 36, after Figure 4.2: "This table is replenished": "This table is supplemented"
Page 36, Table 4.1, line 2: "limited receiving power": "limiting receiver power"
Page 38, paragraph 1, line 8: "In principle there are two ways how to reach it": "In principle, there are two ways to find it,"
Page 38, 1st line after Equation 4.6: "Apparently, tan hr cot zr <= 1 in order the equation (4.6) could be solved.": "We see that tan hr cot zr must be less than or equal to one if a solution to equation 4.6 exists."
Page 38, point 1., line 5: "usually choose the one with respect to familiarity with the terrain": Not sure what is meant. Maybe: "usually choose one based on familiarity with the terrain"
Page 38, point 1., line 7/8: "we fix the sensitivity into the radar antenna pattern and this provides us with the observation with constant sensitivity.": "we take the radar antenna pattern into account, which provides us with observations at constant sensitivity."
Page 39, paragraph 2, line 2: "always keep in mind the way of observations because due to the variable mutual position of the": "always keep in mind the method of observation, since, due to the"
Page 41, paragraph 1, line 1: "Mass distribution index s is a very important to an inner structure": "The mass distribution index s is a very important parameter of the inner structure"

Page 41, paragraph 2, line 4: "A derivation given bellow help us to clarify terms": "The derivation given below helps us to clarify the terms"
Page 44, paragraph 1, line 4: "Calculation the logarithm": "Calculating the logarithm"

Chapter 5: Range distribution model
Page 45, paragraph 1, line 1: "By means of observations we gain the data the characteristics of which": "We collect data from observations, the characteristics of which"
Page 47, line 1: "to include only observable one.": "to include only an observable one."
Page 47, line 7: "Because our observations belong only to single station ones": "Because our observations are only single station"
Page 47, line 15/16: "Their duration are handy because it does not depend": "Their durations are useful because they do not depend"
Page 49, line 1: "The physical meaning have only two last quantities": "Only the last two quantities have physical meaning"
Page 50, paragraph 3, line 5: "The Geminid radiant culminates": "The Geminid radiant transits"
Page 51, 1st line after (5.19): "The good initial estimate of searched parameters are necessary in order the Gauss-Newton method could work.": "A good initial estimate for each parameter is necessary to make the Gauss-Newton method work."

Chapter 6: Results
Page 54, paragraph 1, line 2: "there are the data overview": "there is an overview of the data"
Page 54, paragraph 1, line 5/6: "From that time the unique four long-term series of data have been managed to accumulate.": "In that time, four long-term series of data have been accumulated."
Page 55, line 4: "due to reparations of the radar": "due to repairs on the radar"
Page 55, line 16/17: "we have restricted themselves to": "we have restricted them to"
Page 55, line 20: "was so bad determined": "was so poorly determined"
Page 55, line 23: "the favorite conditions": "favorable conditions"
Page 59, line 2: "for various kind of meteoroid substance provided a spherical shape": "for various meteoroid compositions, assuming a spherical shape"
Page 59, section 6.2.1, line 1/2: "belongs together with Geminids and Perseids to most prominent showers.": "belongs with the Geminids and the Perseids as one of the most prominent showers."
Page 60, line 1/2: "for 2005 brings the population index": "for 2005 gives a population index of"
Page 60, last line: "Our finding conforms the behaviour": "Our finding confirms the behaviour"
Page 61, section 6.2.3, paragraph 2, line2: "we could have not investigate": "we could not investigate"
Page 64, section 6.2.5, line 5: "they have not been proceeded": "they have not been processed"
Page 64, section 6.2.5, paragraph 3, line 8: "rather precisious values": "more precise values"
Page 65, section 6.2.6, line 1: "shower activity was at Ondrejov in 1998, too.": "shower activity was observed at Ondrejov in 1998."

Page 77, line 1/ 2: "shower meteors which have observed by the Ondrejov": "shower meteors which have been observed by the Ondrejov"
Page 77, line 3: "theory of meteors with the neglection of the deceleration": "theory of meteors, neglecting the deceleration"
Page 78, 1st line after Table 7.1: "the possible interval of [sigma] assuming various bulk density of meteoroids to get value": "the possible range of [sigma] by assuming various bulk densities of meteoroids to get the value"
Page 79, second bullet point, line 5: "being about twice lower": "being about twice as low"