



Cornell University
Laboratory for Elementary-Particle Physics



Validation of the HOM Loading Calculation in Bmad and Calculations of Orbit Distortions Induced by Cavity Offsets in the CERN 8.1 Lattice

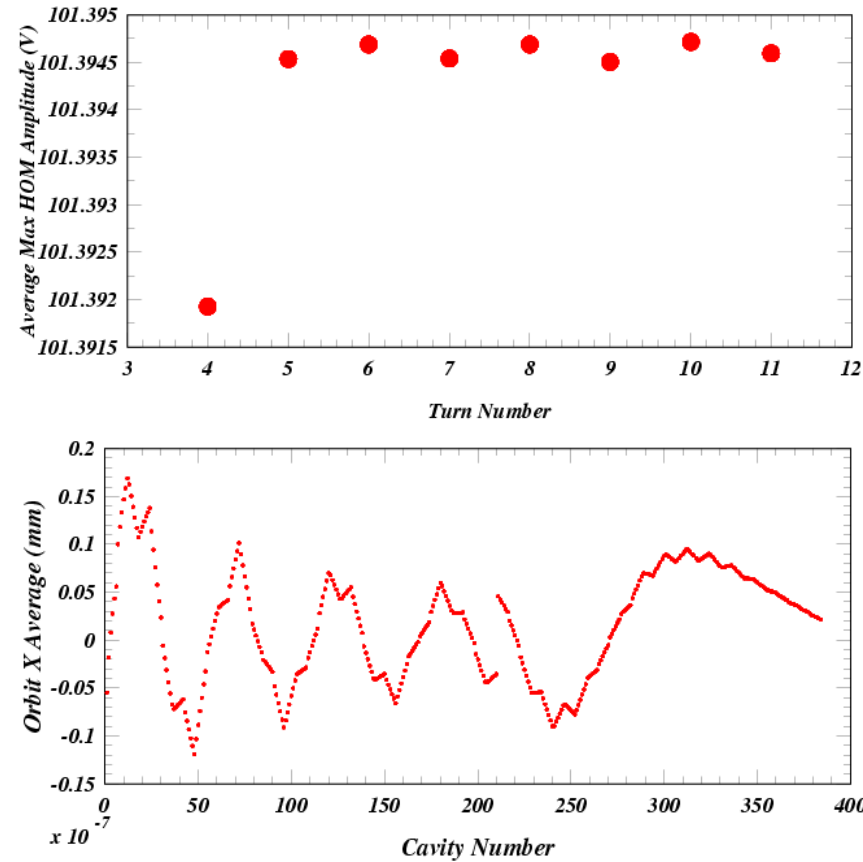
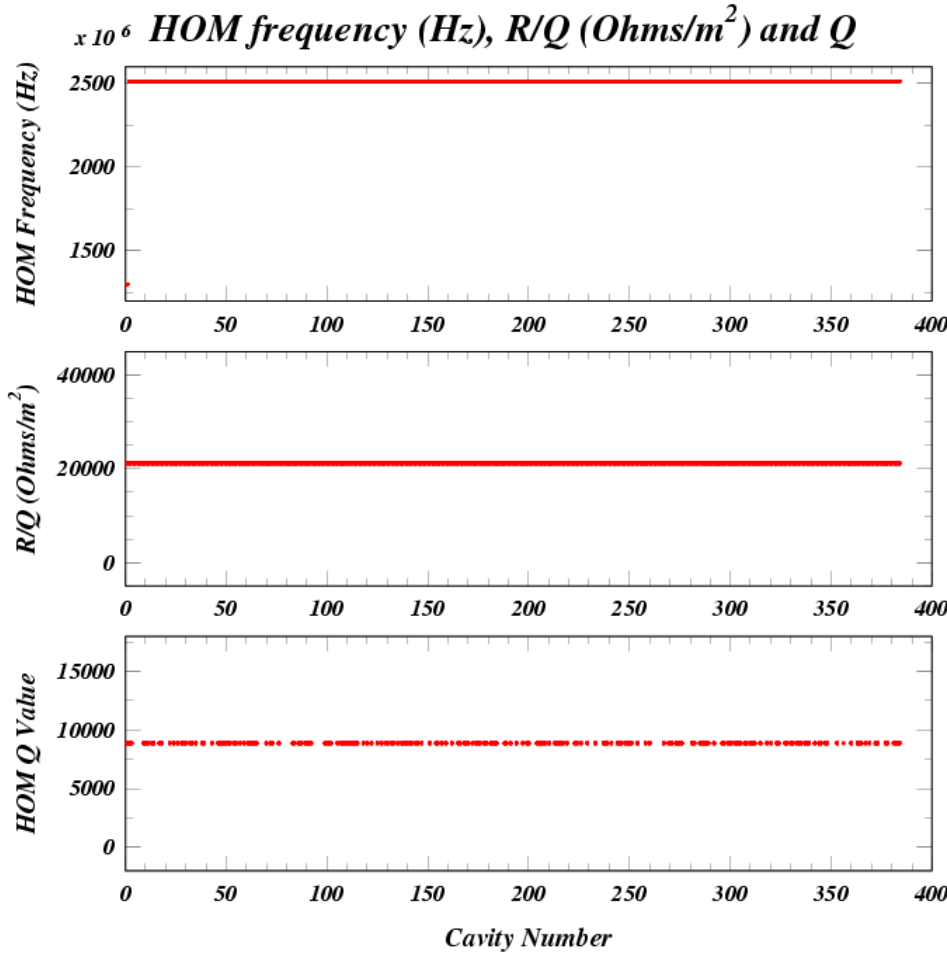
J.A. Crittenden, Georg Hoffstaetter, Chris Mayes and David Sagan

Cornell Laboratory for Accelerator-Based Sciences and Education

ERL@CESR Meeting

23 September 2010

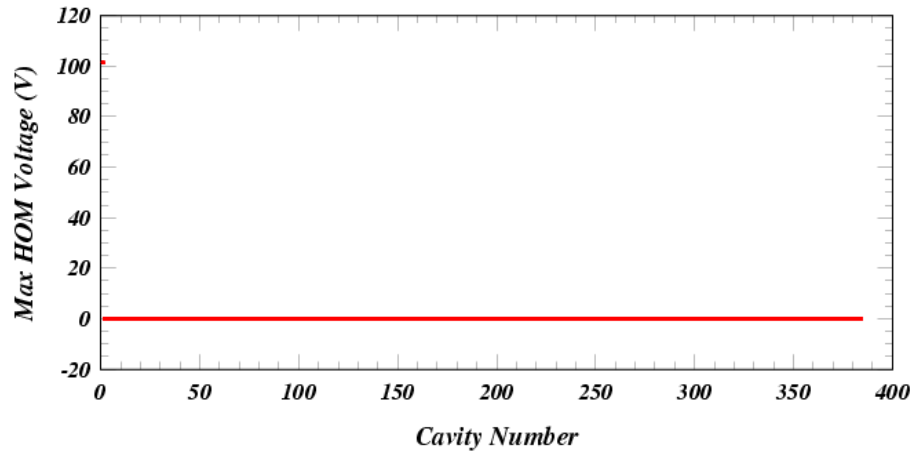




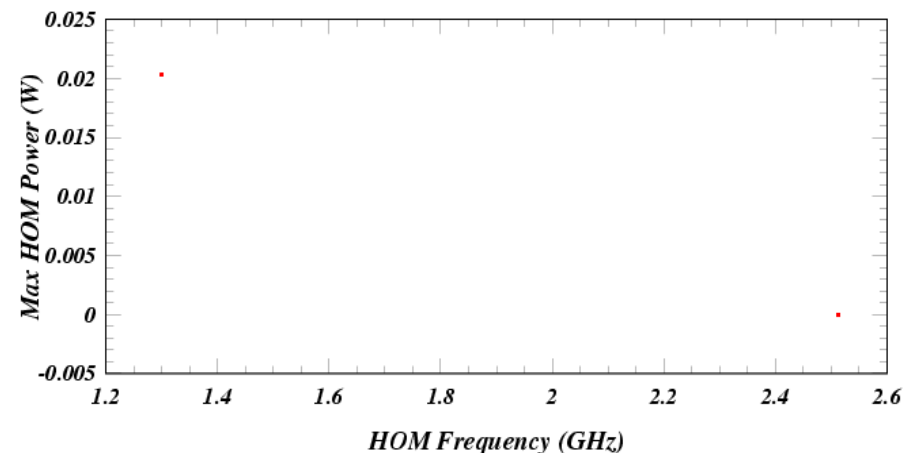
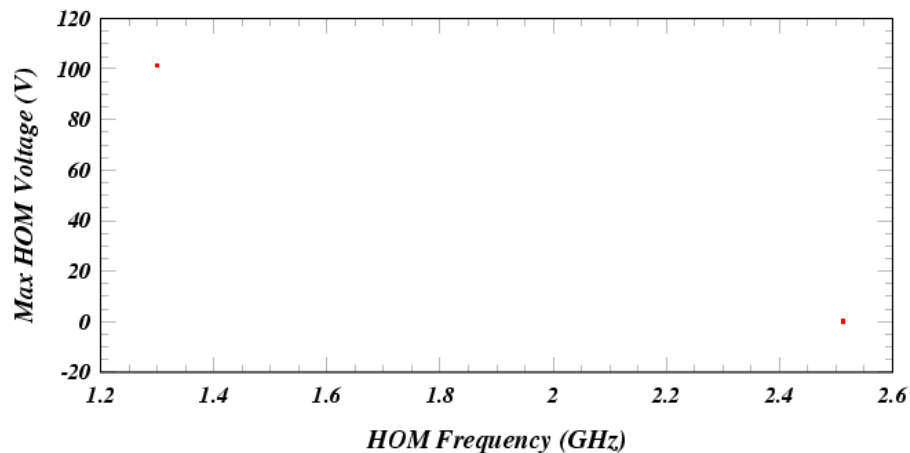
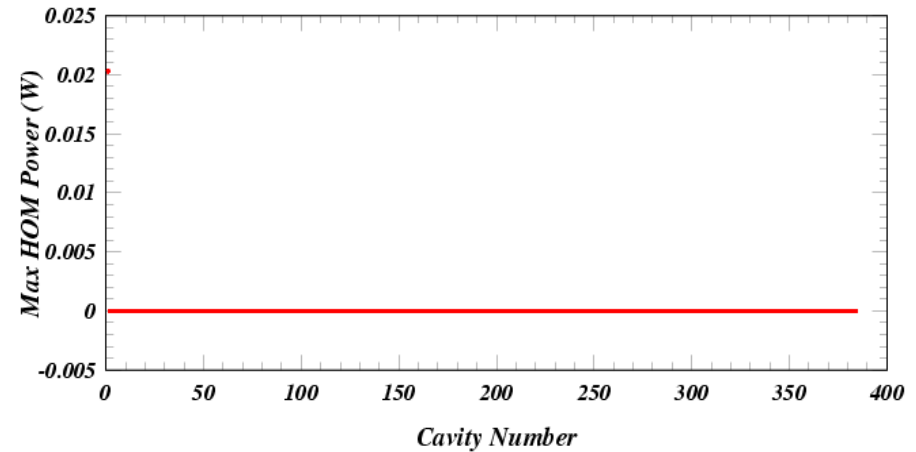
*Resonant HOM in the first cavity. Equilibrium orbit reached after five turns.
Orbit offset in first cavity 55 microns.
Analytic calculation of the excited HOM voltage kick: 100 V.*



Job 326: Max HOM Voltages (V)



Job 326: Max HOM Power (W)



Bmad calculation of HOM voltage as expected. HOM power directly related.

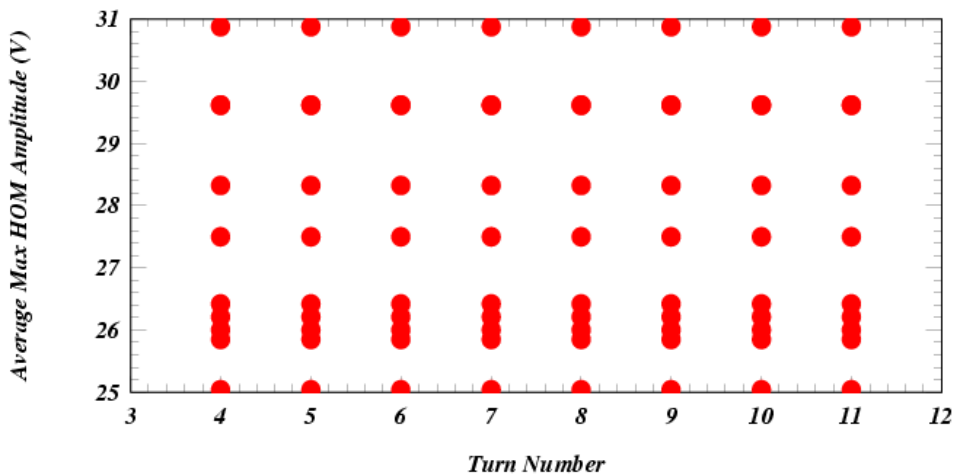


Frequency [Hz]	R/Q [Ohm/m ^ (2n)]	Q	n	Polarization_Angle [Radians/2pi]
&long_range_modes				
1r(1) = 2.512896E+009	21180	8867	1	0.00
1r(2) = 2.513556E+009	76777	1472	1	0.00
1r(3) = 2.514671E+009	81083	8557	1	0.00
1r(4) = 3.068192E+009	632	186198	1	0.00
1r(5) = 3.073245E+009	3971	64567	1	0.00

Three of the HOM frequencies are within $1\sigma_f$ of twice the fundamental (1.3 Ghz).

The frequency spread is 0.4%, i.e. 10-12 Mhz.

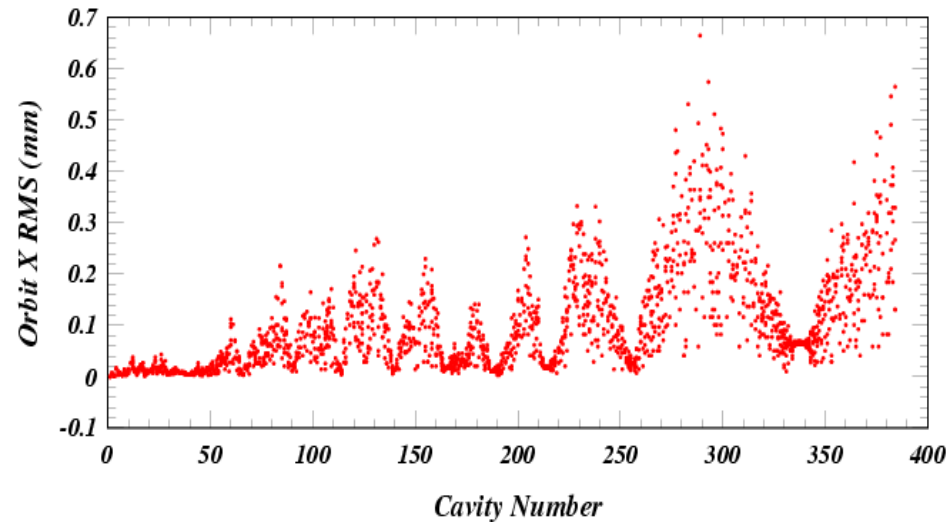
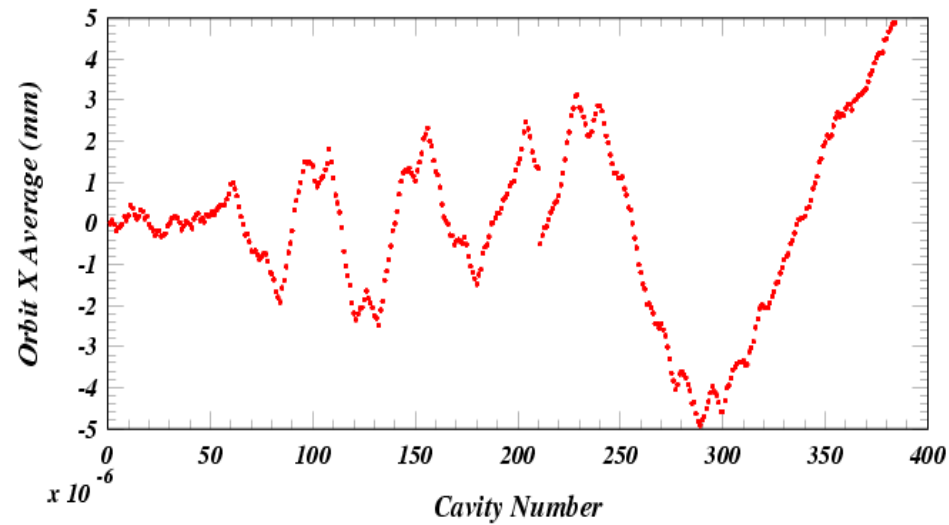
The randomization of the HOM frequencies is limited to $\pm 3\sigma_f$.



*Eleven re-randomizations of HOM frequency.
Equilibrium reached by 4th turn.*

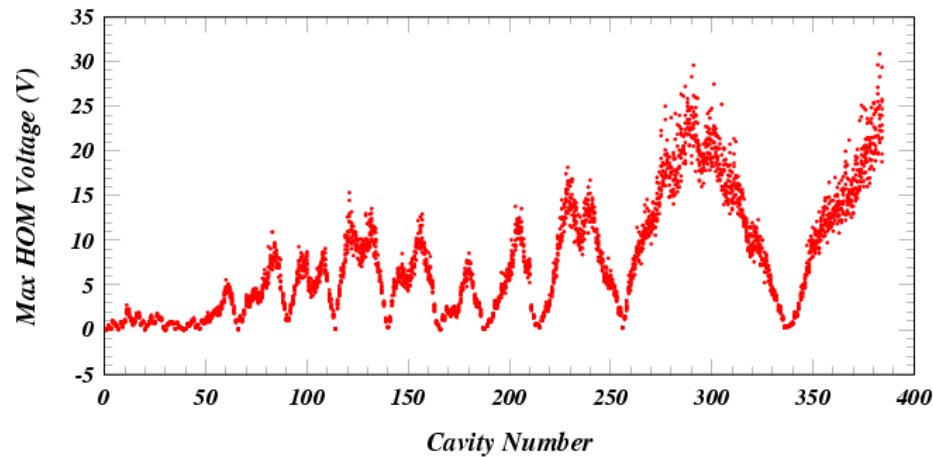
Orbit distortions up to 5mm.

RMS orbit distortions small.

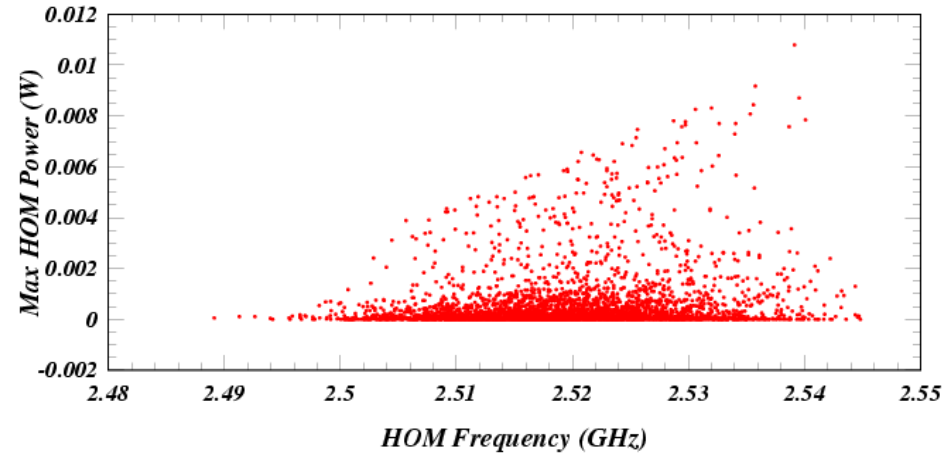
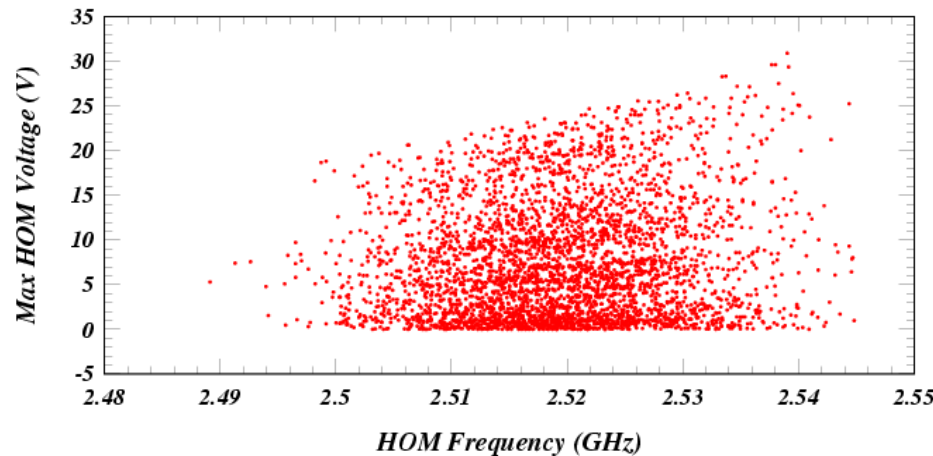
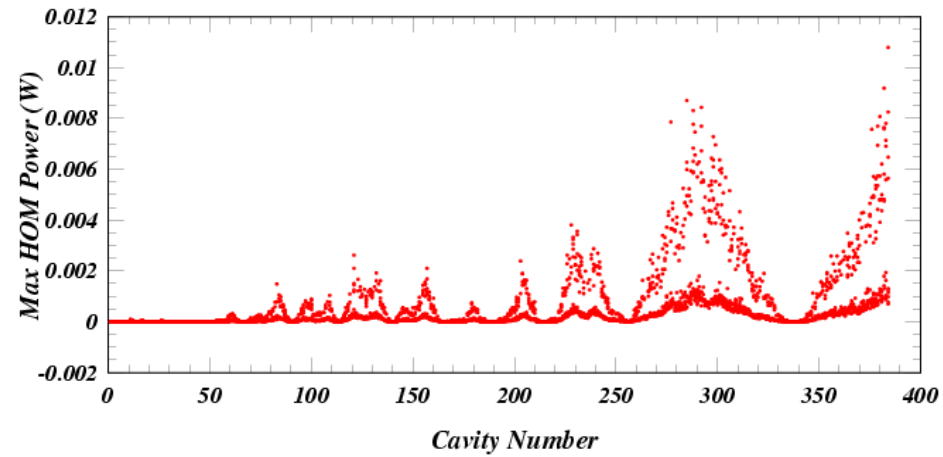




Job 329: Max HOM Voltages (V)



Job 329: Max HOM Power (W)



*Induced HOM voltages increase along linacs, reaching 30 V. HOM power less than 12 mW.
One set of offsets looks much worse than the others.
HOM excitation higher for frequencies closer to twice the fundamental.*



BBU_PROGRAM: Simulation of the Beam Breakup Instability

J.A. Crittenden, D. Sagan

September 20, 2010

1 Introduction

BBU_PROGRAM is a program which simulates the beam breakup instability [1]. The beam breakup instability occurs when a particle beam is recirculated through a cavity as in an Energy Recovery Linac. The bunches of the beam are kicked by the wakefields in a cavity and this kick generates an orbit distortion so that when the bunches return to the cavity, their off-axis orbit through the cavity will create additional wake fields. Given the right conditions, this regenerative feedback can lead to instabilities. BBU_PROGRAM works by direct simulation. A train of bunches is tracked through a lattice and the wakefields and orbit can be monitored.

2 Simulation technique

In order to correctly calculate the HOM fields, bunches are tracked through a given cavity in the correct time order. That is, BBU_PROGRAM “simultaneously” tracks a sequence of bunches that fill the lattice, starting and stopping bunches as appropriate to make sure that the bunches going through a cavity are tracked in the correct order.

In BBU_PROGRAM, time (t) is measured in “turns” (Abbreviated “T”). One turn is the time it takes a bunch to travel from the start of the lattice to the end. At the start of a simulation, at time equal zero, the HOM power in the cavities is set to zero. Bunches are then started at the beginning of the lattice and tracked through to the end. To minimize computation time, a single particle is used to represent each bunch.

Bunches that are initialized at a time between 0 and $1T$ are given a random transverse offset. The offset distribution is Gaussian in shape and the sigma is determined by the parameter `bbu_param%init_particle_offset` (see below). After the zeroth turn period (which is the period $(0 \leq t \leq 1T)$, bunches will be initialized with zero transverse offset. In the second turn period $(2T \leq t \leq 3T)$, the averaged “maximum field strength”, $V_{max}(2)$ which is the field strength of the strongest HOM mode in all the cavities, is taken as a baseline to determine whether the fields are growing or decaying. At the end of the simulation, after a set number of turn periods n , the beam is declared stable or unstable depending upon whether the ratio $V_{max}(n-1)/V_{max}(2)$ is less than or greater than 1. Additionally, in order to shorten the