

2013
100-1033

On the Mechanism for a Gravity Effect using Type II Superconductors

Glen A. Robertson

Advanced Systems and Technology Office, NASA-Marshall Space Flight Center, Huntsville, Alabama 35812

ABSTRACT

In this paper, we formulate a percent mass change equation based on Woodward's transient mass shift and the Cavendish balance equations applied to superconductor Josephson junctions. A correction to the transient mass shift equation is presented due to the emission of the mass energy from the superconductor. The percentage of mass change predicted by the equation was estimated against the maximum percent mass change reported by Podkletnov in his gravity shielding experiments. An experiment is then discussed, which could shed light on the transient mass shift near superconductor and verify the corrected gravitational potential.

INTRODUCTION

Eugene Podkletnov has reported that a gravity shielding effect was seen above a YBCO superconductor being rotated by a magnetic field and irradiated by RF energy.^[1] The mechanism for this phenomenon is as debatable as the test itself. Independent of Podkletnov and about the same time, Torr and Li published several papers on the possible connection between gravity and superconductors.^[2-4] These papers suggest that the gravity mechanism arise from the spin of the lattice ions aligned by an applied magnetic field. In 1995, Becker a student of Torr, showed mathematically that a significant size gravito-magnetic field could exist along with a magnetic field whenever there is flux pinning or other forms of flux trapping in a type II superconductor.^[5] Modanese, a close contact to Podkletnov, has presented a theoretical model from Podkletnov's experimental results.^[6] The model, which is based on the "anomalous" coupling between Bose condensate and the gravitational field, suggests that the essential ingredient for the shielding is the presence of strong variations or fluctuations of the Cooper pair density in the disk.

The behavior of the Bose condensate of Cooper pairs within superconducting materials in an external gravitational field has been the subject of some study in the past.^[7] M. Casas, et al, recently suggested that Cooper pairs lead to Bose condensation at temperatures substantially greater than those of the BCS theory of superconductivity.^[8] In an unpublished paper presented to the author for review, Noever and Bremner suggest such a connection by indicating that superconductors could modulate the background quantum ZPF.^[9] Stirniman presents a related historical overview leading up to gravity's relationship to the superconductor.^[10] Other papers have even suggested a connection between gravity and electrons.^[11,12]

In this paper, it is suggested that a combination of flux pinning and Cooper pair fluctuating across Josephson junctions produce a mass change about the superconductor. An equation for the mass energy produced across the Josephson junctions and an equation for the percentage of mass change is derived from Woodward's transient mass shift equation.^[13] A correction to the gravitational potential Woodward used in the equation is presented. The correction implies the emission of mass energy from the superconductor. The percentage of mass change predicted by this equation was estimated against the maximum percent mass change reported by Podkletnov in his gravity shielding experiments. An experiment is then discussed, which could shed light on the transient mass shift near superconductor and verify the corrected gravitational potential.

BACKGROUND

Of what is known of the type II, YBCO superconductor disk used in the Podkletnov experiments; it seems certain that a large number of superconductor-oxide-superconductor Josephson junctions exist within the disk. In the general sense, Josephson junctions are very small capacitors with the electrodes composed of superconductor material and the dielectric composed of an oxide layer.^[14, pg. 196-286] Unlike normal capacitors, Josephson junctions exhibit a unique property. They radiate RF energy when traversed by a current and generate a current when radiated with RF energy. This would indicate a fluctuation of energy across the junction.

With this in mind, it must be noted that the procedure for making the superconductor disk, including the pressing and sintering of varying size SC grains, produces a structure having many flux pinning sites around which exist the Josephson junctions. Flux pinning is a well-known phenomenon associated with Type II superconductors where magnetic flux is trapped inside a superconductor. Flux pinning results from any spatial inhomogeneity of the material, such as impurities, grain boundaries, voids, etc. To be most effective, these inhomogeneities must be on the scale of the order of the penetration depth or the coherence length, i.e. $\sim 10^{-6}$ to 10^{-5} cm, rather than on the atomic scale where inhomogeneity causes electronic scattering which limits the mean free path.^[14, pg. 166] This so happens to be in the range of the size superconductor powders used to make Podkletnov's disks.

In order for the magnetic flux to remain trapped, a current loop forms around the holes created by the superconductor particles. It would therefore seem that Podkletnov has produced a device that allows flux pinning to enhance the production of RF energy and RF energy to enhance the production of superconductor currents. These reinforcing phenomena should lead to high electron densities or super currents in the superconductor disk. These currents are focused between the superconductor particles, which are Josephson junction sites.

TRANSIENT MASS SHIFT

During a review of current literature for clues on the connection between mass energy and superconductors, it was found that Woodward, who has done some very interesting work with capacitors, both theoretically and experimentally, has come up with an equation for a transient mass shift derive from Mach's Principle.^[13] Mach's Principle explains inertia – the tendency of an object to resist acceleration – by the sum of the gravitational attractions of all objects in the universe. Woodward presented the transient mass shift dm_0 as

$$\partial m_0 = \frac{\beta w P_0}{2\pi G \rho_0 c^2} \quad (1)$$

Where dm_0 is the transient mass shift; β is the ratio ϕ / c^2 (ϕ is the gravitational potential due to all the matter of the universe) and is approximately 1 and unitless; w is the frequency of the driving voltage into the capacitors in radians per second; P_0 is the power applied to the capacitors in ergs/s (10^7 ergs/s = 1 Watt); G is the gravitational constant = 6.67×10^{-8} dyne cm^2/gm^2 ; ρ_0 is the density of the capacitors; and c is the velocity of light in $\text{cm} / \text{s} = 300 \times 10^8$ cm/s.

A Cavendish balance, which is routinely used to measure the gravitational constant G allows for the expression of G in terms of measurable quantities, which are

$$G = \phi \frac{b^2 l}{8M} \left(\frac{2\pi}{T} \right)^2 \quad (2)$$

Where M is the test mass (superconductor), b is the distance between the center of a known mass m and the test mass M , l is the separation distance of the masses m on a torsion bar, T is the period of the damped harmonic motion of the torsion bar, and ϕ is the angular displacement of the torsion bar caused by the motion of the test masses. Note that the result is independent of the value of m and can be written in the following simplified form

$$\phi = T_c GM \quad (3)$$

Where $T_c = (8/b^2 l)(T/2\pi)^2$ is a proportionality constant associated with the torsion balance characteristics.

If perceptible transient mass shift could be demonstrated with a Cavendish balance, the change in the measured angular displacement of the torsion fiber will be directly proportional to the test mass change, assuming the gravitational constant is unaltered. For example, the change in angular displacement $d\phi$ associated with an effective change in test mass dM due to gravitational modification is given by

$$\partial\phi = T_c G \partial M \quad (4)$$

By combining equations 4 with equation 1, the change $d\phi$ in the angular displacement ϕ due to a mass change dM can be expressed in engineering terms as

$$\partial\phi = \frac{T_c \beta f_i P_i}{\rho_0 c^2} \quad (6)$$

Where f_i is the frequency (in Hz) of the effective input power P_i (in watts).

By setting equation 3 equal to equation 4 through the constant $T_c G$, a relationship between the two angular displacements and the masses can be made. From this relationship, a percent change in mass can be expressed by

$$M\% = \frac{\partial M}{M} * 100 = \frac{\partial\phi}{\phi} * 100 \quad (7)$$

Using $d\phi$ as defined by equation 6 and ϕ as defined by equation 3, the percent change in mass can be expressed as

$$M\% = \left[\frac{\beta f_i P_i}{GM \rho_0 c^2} \right] * 100 \quad (8)$$

In the Podkletnov experiments, the percent change in mass of an object placed above the superconductor disk was maximized at 2%. Assuming the same for equation 8, then $M \rho_0$ is on the order of $10^{12} \text{ kg}^2/\text{m}^3$ with $f_i = 10^6 \text{ Hz}$ and $P_i = 100 \text{ watts}$. Then it is easily seen that this equation does not make much sense if $M \rho_0$ is that of a typical mass and mass density of a YBCO superconductor ($M \sim 2 \text{ kg}$ and $\rho_0 \sim 50 \text{ kg/m}^3$). Therefore, what are these quantities? It is argued that the mass change is due to electrons, which somehow affects the total mass. It is then stated that in the superconductor ρ_0 is the density of the superconductor (given by ρ_{sc}) and M is the mass of the electrons (given by M_e) involved in the phenomena given by

$$M_e = \frac{I_{ij} \overline{A_{ij}}}{f_{ij} \left(\frac{q_e}{m_e} \right)} \quad (9)$$

Where I_{jj} is the current per area associated with the superconductor Josephson junctions, A_{jj} is the sum of the magnitudes of the normal vector to the cross sectional area of the Josephson junctions, f_{jj} is the Josephson junction frequency, and q_e/m_e is the ratio of charge to mass of an electron ($= 1.759 \times 10^{11}$ coulombs/kg). By incorporating equation 9 into equation 8, then for a superconductor with Josephson junction sites, equation 8 is rewritten as

$$M_{sc} \% = \left[\frac{\beta f_i f_{jj} P_i \left(\frac{q_e}{m_e} \right)}{G I_{jj} A_{jj} \rho_{sc} c^2} \right] * 100 \quad (10)$$

Given the analysis, from which equation 10 was derived, the transient mass shift expression in equation 1 is modified for the superconductor to produce an energy E_{sc} equation as

$$\partial m_e c^2 = E_{sc} = \frac{\beta f_i P_i}{G \rho_{sc}} \quad (11)$$

Where E_{sc} is the energy released during the mass change of the superconductor. Letting $f_i = 10^6$ Hz, $P_i = 100$ watts, $\rho_{sc} = 48$ kg/m³, $G = 6.673 \times 10^{-11}$ N m²/kg², the mass energy radiated by the motion of the electrons across the Josephson junctions is about 10^{16} Joules. Noting that 1 Watt = 1 Joule/s, then the emitted power P_{sc} associated with the mass energy E_{sc} emission can be expressed as

$$P_{sc} = f_{jj} * E_{sc} = \left(\frac{\beta}{G} \right) (f_i P_i) \left(\frac{f_{jj}}{\rho_{sc}} \right) \quad (12)$$

The frequency f_{jj} of the electrons fluctuating across the Josephson junctions is used. Since, the mass energy is being created at this frequency. Letting $f_i = f_{jj}$, the Power P_{sc} emitted is about 10^{22} Watts. How can 100-Watts input produce 10^{22} -Watts output? It is argued that the gravitational potential ϕ about the superconductor is changed due to the emission of the mass energy (E_{sc}). This change results in a change (Δ) in the dimensionless constant β , expressed as

$$\Delta \beta = \left(\frac{\phi + \partial \phi}{c^2} \right) = \frac{\alpha}{c^2} \quad (13)$$

Where α is defined as the new gravitational potential due to the emission of mass energy E_{sc} from the superconductor. Redefining β in equation 10 with $\Delta \beta$ in equation 13 and regrouping the terms, equation 10 can be simplified in terms of the power input and the superconductor properties as

$$M_{sc} \% = \gamma_k * [f_i P_i] * \left[\frac{\alpha f_{jj}}{I_c A_{jj} \rho_{sc}} \right] * 100 \quad (14)$$

Where $\gamma_k = (q_e/m_e)/(Gc^4)$. Now an approximation of the percent mass change in terms of input power and the superconductor can be made. The estimation is presented in figure 1 where $\alpha = .03$, $q_e/m_e = 1.7588 \times 10^{11}$ C/kg, $G = 6.673 \times 10^{-11}$ N m²/kg², $c = 2.9979 \times 10^8$ m/s, $f_i = f_{jj} = 10^6$ Hz, $\rho_{sc} = 48$ kg/m³, and $I_{jj} = 10^3$ amps/cm², $A_{jj} = 0.001$ cm². The term α was chosen to make $P_{sc} \sim 100$ Watts and the magnitude A_{jj} of the Josephson junction cross-sectional area was chosen to make the 2% mass change fall at 100 watts.

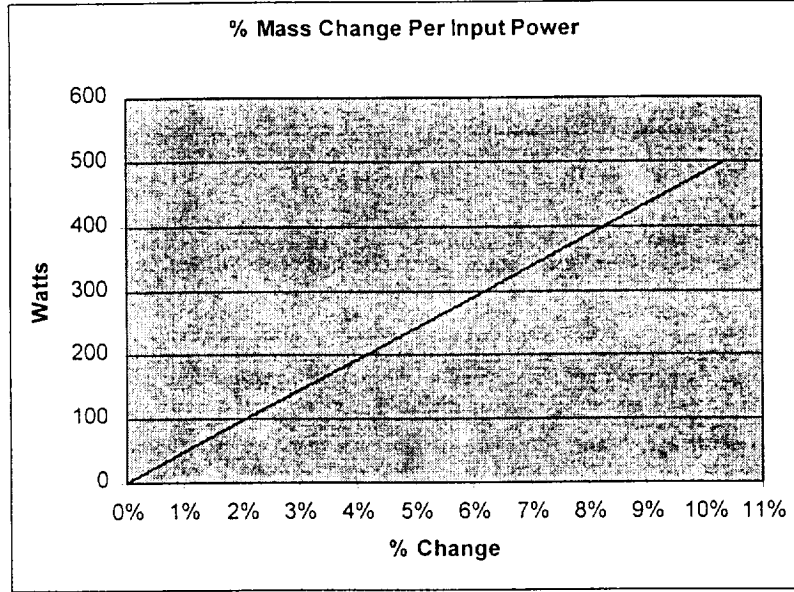


Figure 1

TESTING FOR A TRANSIENT MASS SHIFT

The corrected gravitational potential α can be perceived as the only unknown in equation 14. However, the values for I_{jj} and A_{jj} were chosen to fit the predetermined notion of Podkletnov's experiment. With this in mind, the ratio $\alpha/(I_{jj} A_{jj})$ is the real term in question with respect to a transient mass shift about a superconductor as just changing one of these terms without changing the others could implies an energy loss or gain. Reproduction of the YBCO disk used in Podkletnov's experiments should lead to reasonable values for I_{jj} and A_{jj} . In addition, the direction of the vector sum of the magnitude of A_{jj} should be predominately in the plane perpendicular to the direction of the pressuring force applied to make the disk. The pressing plane used to make Podkletnov's disks was in the plane of rotation, which is perpendicular to the effective force seen on the test masses. Given this assumption the pointing vector associated with the Josephson junctions would be in an upward or downward direction. Due to the two-layer arrangement of the disk and the fact that no change in mass was seen for a mass placed below the disk, it is argued that it is upward. Also worth mentioning is that I_{jj} was chosen for this estimate as the critical current density of small grain YBCO superconductors produced by the author. It may very well be that I_{jj} is the current density across the junction and not the critical current of the superconductor grains.

Utilizing the previous equations, the ratio $\alpha/(I_{jj} A_{jj})$ can be defined in measurable terms as

$$\frac{\alpha}{I_{jj} A_{jj}} = \frac{1}{\gamma_k} * \left[\frac{\rho_{sc}}{f_i f_{ij} P_i} \right] \frac{\partial \phi}{\phi} \quad (15)$$

Where $d\phi/\phi$ can be experimentally derived using a properly designed Cavendish balance. Figure 2 shows the effect on the transient mass shift changes with the ratio $\alpha/(I_c A_{jj})$ ($= 0.003, 0.03 \& 0.3$). As seen, percent mass change is very sensitive to this ratio.

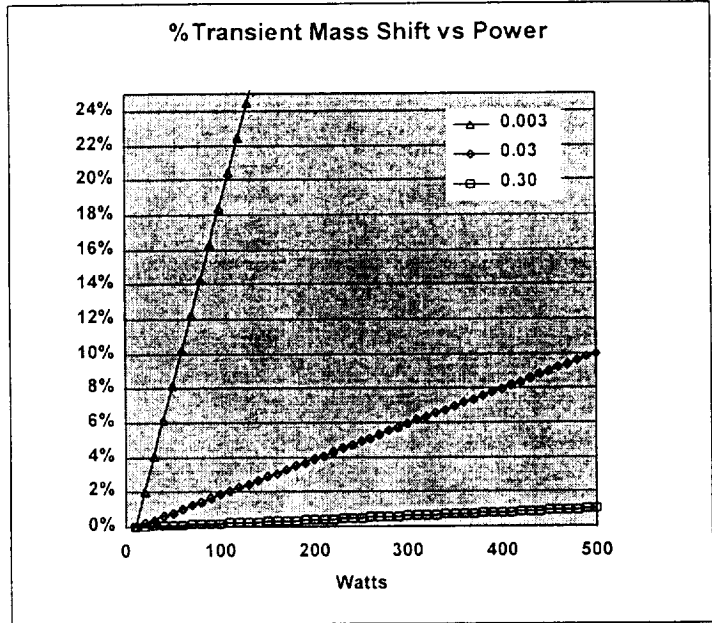


Figure 2

Such an experiment would utilize properly constructed high-T_c oxide superconductors containing multiple Josephson junction sites between superconductor grains. The fabrication of the superconductor would be such that the pressing force was applied perpendicular to the applied magnetic field. This will insure alignment of the Josephson junction predominately in the plane of the magnetic field. Cooper pair super-currents would then be induced across the many Josephson junction sites that are distributed about the flux pinning vortices and modulated by the RF input. A sketch of the proposed experiment is given in Fig. 3. As shown, U-shaped permanent magnets with poles of high field, rare-earth permanent magnets are arranged such that the magnetic field is through a high-T_c oxide superconductor like YBCO. The RF coils are shown for representation. The actual configuration may vary dependent on the frequency required.

From equation 4, an estimate the sensitivity to a transient mass change can be made by making reasonable assumptions for the various balance parameters. Based on the published characteristics of commercially available Cavendish balances, where $T = 120$ sec; $l = 30$ cm; $b = 3$ cm a numerical estimate for the sensitivity is given as

$$\frac{\partial\phi}{\partial M} = 0.7 \text{ microradians / gram} \quad (5)$$

Thus, the sensitivity of a Cavendish balance to small transient mass change effects is generally somewhat limited, and successful detection of these effects will require painstaking efforts in the design and fabrication of the instrument. It will be necessary to push every parameter toward its extreme values in order to achieve the highest possible sensitivity. For example, for a 500 gram superconductor test mass, where the density of the YBCO ceramic is approximately 4.8 gram/cm³, then a 1% change in effective mass ($dM = 5$ grams) due to transient mass change effects would yield a torsional displacement of $d\phi = 3.5$ microradians. This is within the established sensitivity of state-of-the-art torsional displacement transducers, which can easily resolve displacements of less than 1 microradian. Such a Cavendish balance is commercially available from Tel-Atomic.

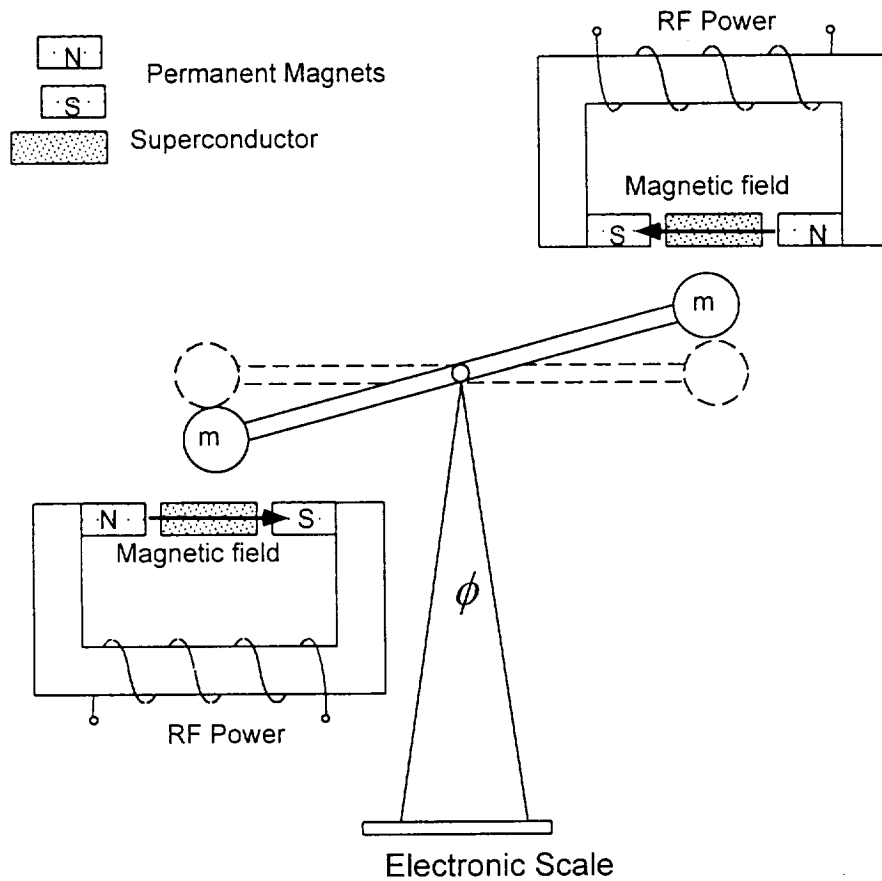


Figure 3

CONCLUSION

Much of the material presented in this paper is clearly hypothetical. The equations are a first order approximation that needs further refinement. For example, the corrected gravitation potential α may also involve an efficiency of the power inputted into the superconductor or the conversion of the power to currents across the Josephson junctions. Although, should a transient mass shift be seen by the described experiment. It would provide the necessary foundation for further work in this area.

This research was supported in part by NASA's Advanced Space Transportation Research, Breakthrough Propulsion Physics. The author wishes to thank R. Litchford for help in the sensitivity analysis of the Cavendish balance and R. Koczor, W. Brantley, and J. Cole for helpful discussions.

References

1. Podkletnov, E. and Nieminen, R. , "A Possibility of Gravitational Force Shielding by Bulk $\text{YBa}_2\text{Cu}_3\text{O}_{7-x}$ Superconductor," *Physica C*, C203, 441-444, 1992 and Podkletnov, E. E., "Weak gravitation shielding properties of composite bulk $\text{YBa}_2\text{Cu}_3\text{O}_{7-x}$ superconductor below 70 K under e.m. field," Published on the web at <http://xxx.lanl.gov/abs/cond-mat/9701074/>
2. N. Li and D. G. Torr, "Gravitational effects on the magnetic attenuation of superconductors," *Phys. Rev. B*, Vol. 46, 1992, p. 5489.
3. N. Li and D. G. Torr, *Phys. Rev. D*, Vol. 43, 1990, p. 457.
4. D. G. Torr and N. Li, "Gravito-Electric Coupling Via Superconductivity," *Found. Phys. Lett.*, Vol. 6, 1993, p. 371
5. Robert Becker, Paul Smith, and Heffrey Bertrand, "Proposal for the Experimental Detection of Gravitomagnetism in the Terrestrial Laboratory," September 1995, Published on the web at <http://www.inetarena.com/~noetic/pls/RBecker/Gmexp2.htm>
6. Giovanni Modanese, "On the theoretical interpretation of E. Podkletnov's experiment," LANL gr-qc/9612022, Presented for the World Congress of the International Astronautical Federation, 1997, nr. IAA-97-4.1.07. and G. Modanese, "Gravitational Anomalies by HTC superconductors: a 1999 Theoretical Status Report," Published on the web at <http://www.gravity.org/nat.htm>
7. D. K. Ross, *J. Phys. A* 16, 1331, 1983, J. Anandan, *Class. Q. Grav.* 11, A23, 1994 and references.
8. M. Casas, Rigo, A., de Llano, M., Rojo, O., Solis, M. A., "Bose-Eistein condensation with a BCS model interaction," *Physics Letters A*, Vol. 245, pg. 55-61, 1998.
9. David Noever, and Bremner, Christopher, "Large-Scale Sakharov Condition," Not published.
10. Robert Stirniman, "The Wallace Inventions, Spin Aligned Nuclei, the Gravitomagnetic Field, and the Tampere 'Gravity-Shielding' Experiment: Is There a Connection?" Published on the web at <http://www.padrak.com/agn/WALLACE.html>
11. Cornille Patrick, "Electrostatic Pendulum Experiment which Pumps Energy from the Ether, Published on the web at <http://members.aol.com/overunity/elecpxp/elecpxp.html>
12. Nils Rognerud, "On the Electromagnetic Nature of Gravity," Published on the web at <http://www.best.com/~rognerud/html/axioms.html>
13. "James F. Woodward: Mach's Principle Weight Reduction = Propellantless Propulsion," (A summary from *Foundation of Physics Letters*, Vol. 9, No. 3, (1996), pg. 247 – 293. Published on the web at <http://www.inetarena.com/~noetic/pls/woodward.html>
14. Tinkham, Michael and Gordan McKay, "Introduction to Superconductivity," McGraw-Hill, Inc., pg. 196-286, 1996.
15. "Physicists Condense Supercooled Atoms, Forming New State of Matter," *Encarta Yearbook*, August 1995. Published on the web at <http://encarta.one.microsoft.com/enarta>