FUSION BY QED CONFINEMENT?

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ABSTRACT

Inertial confinement fusion (ICF) embodies the simultaneous firing of large-scale high-intensity mega-joule laser pulses at targets of pea-sized deuterium pellets. Fusion is initiated as pellet implosion produces temperatures over 100 million degrees and density 1000x normal solid density. The ICF reactors are planned to be a future source of electricity, but their current large-size is unattractive. Recently, neutrons were found in a compact ICF table-top system using a single infrared (IR) milli-joule femto second laser to irradiate submicron droplets in a spray of heavy water. Although convenient, the target droplets lack the confinement that would dramatically improve neutron yield. Encapsulating the submicron droplets in a thin containment shell should improve neutron yield, but based on the prior art in pea-sized targets is not possible because the shell would promptly vaporize under the high implosion temperatures. But quantum electrodynamics (QED) rejects this conclusion for submicron targets. In fact, QED defines the target temperature depending on its electromagnetic (EM) resonance. Pea-sized targets with low EM resonant frequencies in the far IR have finite specific heats that allow the absorbed IR photon to be conserved by an increase in target temperature. But the specific heat vanishes for submicron targets having high EM resonance at visible (VIS) frequencies and beyond, and therefore the IR photon cannot be conserved by an increase in target temperature. Instead, the absorbed IR photon constrained by QED confinement undergoes frequency up-conversion to the target EM resonant frequency, the absorption of successive laser IR photons cumulatively increasing the EM energy level of the target to a few MeV per heavy water molecule Thus, the absorbed IR photons are conserved by multiple ionization of the target ions. Promptly, the electrons escape, leaving the charged ions at MeV energies in a highly repulsive Coulomb state. Since QED confinement increases the EM energy of the target and not its temperature, the containment shell remains intact at least until fracture, thereby allowing fusion to be initiated with a high neutron yield under Coulomb pressures as high as 7000 bar. Although ICF reactors with submicron targets is a significant advancement over the prior art, any improvement in neutron yield by QED confinement may be inconsequential because the important economic issues of the cost of the submicron targets and disposal of containment shells remain to be resolved. Because of this, extensions to this paper consider more immediate applications of the ICF submicron targets, specifically providing artificial lighting that does not require electricity. By replacing the heavy water in the submicron ICF targets with light water doped with light sensitive Luminol or Rhodamine 6G, a large number of submicron targets may be configured into compact VIS light sources that operate solely from the thermal energy in the ambient environment, or at the very least by enhancing the artificial light from conventional sources.

Key Words: laser fusion, submicron targets, spray, heavy water, QED, artificial lighting

1 INTRODUCTION

Inertial confinement fusion (ICF) embodies [1] the simultaneous firing of large-scale multiple high-intensity mega-joule laser pulses at targets of pea-sized deuterium pellets. Fusion is initiated on the premise that temperatures over 100 million degrees and density 1000x normal solid density are produced in pellet implosion. Large scale lasers are needed to generate the high intensity pulses necessary to achieve these temperatures and pressures, e.g., the proposed National Ignition Facility [2] is a 192-beam 2 MJ laser systems.

However, large scale laser systems producing high temperatures and pressures in pea-sized deuterium pellets are not necessary to initiate fusion. With submicron targets, fusion has been initiated in significantly down-sized table-top systems with femtosecond lasers, e.g., 815 nm lasers depositing ~ 35 femto-second pulses of 120 milli-joules [3-5]. Submicron deuterium cluster targets of diameter 5 nm are found [4] to yield about 10^5 neutrons per joule of laser energy. Similar yields are found for deuterium sprays with larger 150 nm diameter targets. In contrast, experiments [6] with 1 micron diameter droplets have produced x-rays, but no evidence of fusion. Why is the size of the deuterium targets crucial to initiating fusion reactions with the femtosecond lasers?

To answer this question, one has to turn to the interaction of the laser pulse with cluster and spray droplet targets. In this regard, many studies [7] have been motivated by a desire to generate photons and particles with energies far above the energy of a single laser photon. The conservation of EM energy forbids the generation of photons and particles having more energy than the laser photon, and therefore it is necessary to search for mechanisms that gather the laser photons and collectively combine them into higher energy photons and particles.

Whether the submicron targets are gas or solid is clearly an important consideration. Soft x-rays in the 30-100 eV range are obtained by focusing the laser pulse into a static filled gas cell or at the output of a pulsed gas jet. But the inability of gases to convert laser light into x-rays has led to the conclusion [7] that gases are not good absorbers of laser irradiation. However, this conclusion is not consistent with the Mie theory [8] that expects gas molecules small relative the photon wavelength to fully absorb the laser radiation.

On the other hand, solid targets [7] having the capability of producing photons and particles in the MeV range are considered to be high absorbers of laser radiation. Conversion of nearly 1% of the laser light into x-rays in the 1-keV range have been demonstrated and can be increased to 10% when the surface of the target is coated with a porous layer of gold-black composed of 10 nm clusters of gold. Because of the high surface to volume ratio, the gold clusters are highly efficient in absorbing laser radiation than the conventional flat gold targets.

That clusters are important in absorbing laser energy is exhibited by strong soft x-ray emission from large C_{60} carbon molecules, and therefore the conclusion in [7] that molecules are not good absorbers of laser radiation should be qualified. Clearly, how the molecule partitions the laser energy is important in order to explain the soft x-rays found in C_{60} as opposed to the lighter molecules. Small molecules having fewer degrees of freedom cannot partition the absorbed photon into higher energy states necessary for ionization. Nevertheless, submicron targets comprising clusters of both solid and gas phases appear as a conceptual optimum for absorbing laser energy.

High-pressure gas jets provide a convenient way [7] of producing solid density clusters from the cooling associated with the adiabatic expansion of the gas into vacuum. When the jet backing pressure exceeds a few atmospheres, clusters (10^4 atoms) form in the inert gases. Laser irradiation at 248 nm and power ($0.5\text{-}80\text{x}10^{17}$ W/cm^2) focused into a jet of Xe gas showed the clusters serve only to absorb the laser energy; the bulk of the x-ray emission occurring after the cluster has expanded. The mechanism by which the laser energy is thought coupled into the clusters is by collisional heating of electrons. To improve the neutron yield clusters ($> 10^4$ atoms) are required, but are difficult to form in jets.

More recently, heavy water spray droplet targets [5] of about 150 nm diameter were irradiated with 35 fs pulses of 810 nm laser at power ($1\text{x}10^{19}$ W/cm^2). Due to the 10-50 times larger size of the droplets compared to the clusters, the deuterons following Coulomb explosion reach energies up to 1 MeV. The submicron water droplets contain enough

molecules to build an enormous Coulomb potential if somehow they are all ionized. Taking a simple electrostatic sphere of diameter d_{sp} = 150 nm, particle density $n_o = 3x10^{22}$ cm^{-3}, and assuming an average charge state Z = ± 1 per particle, q is the unit charge, and relative dielectric constant e_r = 1, the sphere potential E_{pot} is,

$$E_{pot} = \frac{Zq^2 d_{sp}^2 n_o}{12\varepsilon_0} \sim 1\text{MeV} \qquad (1)$$

But how does the submicron droplet ionize? In answering this question, there are a few problems [9]. The first problem is how the Mie resonance can be excited with laser photons having several times lower frequencies. One explanation is the reduction of the Mie resonance as the cluster is expanding provided this occurs while the laser pulse is still on. If the cluster is fully ionized, the time [10] to double its radius is around 100 fs. However, this is thought [9] questionable for large clusters because complete ionization will take several times longer. On this basis, a three-photon excitation of the Mie resonance was proposed [9] to explain the production of multiply charged ions. Prior models explained multiple-ionization of cluster atoms by binary collisions or excitation of Mie resonance. However, the three-photon ionization is restrictive to explain the ionization found in a wide range of fusion targets.

A more basic explanation of how the Mie resonance is excited is necessary. One such explanation is QED confinement of EM radiation [11] given in this paper.

2 PURPOSE

In support of the ICF reactors for the production of commercial electricity, the purpose of this paper is to explain how the QED confinement of absorbed laser IR photons is significantly enhanced in submicron target compared to the pea-sized predecessors.

But the QED confinement of EM radiation is a general concept and need not be specifically directed to the production of commercial electricity in ICF reactors. Extensions of the submicron ICF targets are made to providing a source of artificial VIS lighting using the IR radiation in the ambient thermal environment, or enhancing the VIS light of conventional lighting.

3 CONCEPT

In the QED confinement of EM radiation, compact ICF reactors using submicron targets having a size smaller than the wavelength of the surrounding EM radiation are of interest. The submicron targets are heavy water droplets encapsulated in a containment shell, the irradiation of which with intense milli-joule femtosecond IR lasers initiates fusion with the neutrons providing a source of heat that through a thermal power cycle produces electricity.

However, the same targets using light water and light sensitive Luminol or Rhodamine 6G dopant may also be used directly to produce a source of artificial light, thereby foregoing the need of an ICF reactor to produce the electricity to power the artificial lighting. Intense IR lasers are not required. Although low-level artificial light is produced, the targets only require the far IR radiation available in the ambient thermal environment or at the very least the waste heat from conventional sources of lighting.

4 ANALYSIS

The ICF submicron target of heavy water encapsulated in a spherical containment shell is illustrated in Fig. 1. By the Mie theory, the laser IR photons are fully coupled and absorbed within the volume of the submicron targets having a diameter less than the IR laser wavelength. Pea-size ICF targets having diameters larger than the IR laser wavelength do not efficiently absorb the laser IR photons because the coupling to the target is by ablation of the surface. This difference in the size of ICF targets is crucial in whether the absorbed laser IR photon is conserved in the target by an increase in EM or thermal energy.

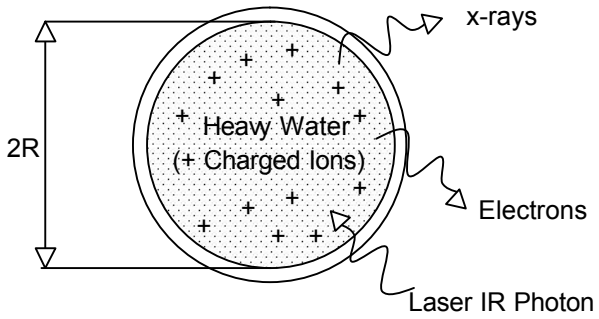

Figure 1. Submicron ICF Target

Unlike pea-sized ICF targets, the short EM resonant wavelength of submicron targets limits the thermal kT energy allowed to be absorbed to insignificant levels, and therefore the absorbed laser IR photons cannot be conserved by an increase in temperature. Instead, the IR photon within the QED confinement of the submicron target is conserved by increasing the target EM energy. This is analogous to the classical example of increasing the EM energy in a box with the addition of photons having a frequency equal to fundamental EM resonant frequency of the box. Once the fundamental mode is filled, higher harmonic modes are next filled, and so on, until the box contains EM energy at very high frequency.

In QED confinement, the Mie resonance is excited in the process of frequency up-conversion of the successive laser IR photons. Absent a thermal path to conserve the absorbed IR photon, the EM energy in the target increases without bound, currently [5] to a few MeV per heavy water molecule. The target promptly ionizes with the escaping electrons leaving behind a highly positive Coulomb charged target. Since the target cannot absorb the IR laser photon by an increase in temperature, the containment shell remains intact allowing Coulomb pressure to increase and initiate fusion with high neutron yield.

The ICF target containment shell may sustain a high Coulomb pressure P because the thickness t_w is of the same order at the target radius R,

$$P = 2\frac{t_w}{R}\sigma_P \tag{2}$$

where, σ_P is the yield stress [12] of the shell material. For SiC, $\sigma_P \sim 2680$ MPa. Taking $t_w \sim$ 10 nm for R = 75 nm gives P = 715 MPa = 7150 bar. This is a significant improvement over the heavy water spray at 1 bar pressure.

The Planck energy E_T of the resonant target photons,

$$E_T = \frac{hc}{\lambda_T} = \frac{hc}{4Rn_r} \tag{3}$$

Taking the submicron target [5] of a 150 nm heavy water droplet, $\lambda_T = 400$ nm and $E_T = 3.11$ eV. A typical Mie resonant wavelength $\lambda_{Mie} = 300$ nm and $E_{Mie} = 4.14$ eV. In contrast, the laser IR photon has $\lambda_{Las} = 810$ nm and $E_T = 1.53$ eV. In the x-ray region, the single heavy water molecule of dimension 0.3 nm may be considered to have an EM resonant wavelength $\lambda_{x\text{-}ray} = 0.6$ nm and $E_{x\text{-}ray} \sim 2$ keV.

Whether the ICF target temperature increases or not depends on its EM resonant wavelength λ in relation to the dominant IR wavelength λ_{IR} at its temperature prior to IR photon absorption. This can be understood by the Einstein-Hopf relation for the harmonic oscillator [13] shown at ambient temperature in Fig. 2. The dominant IR wavelength λ_{IR} corresponds to the minimum wavelength above which most of where most of the thermal kT energy E_{avg} resides. At ambient temperature, the Planck energy E_{avg} saturates to kT ~ 0.0258 eV above about 100 microns, and therefore the dominant IR wavelength $\lambda_{IR} \sim 100$ microns.

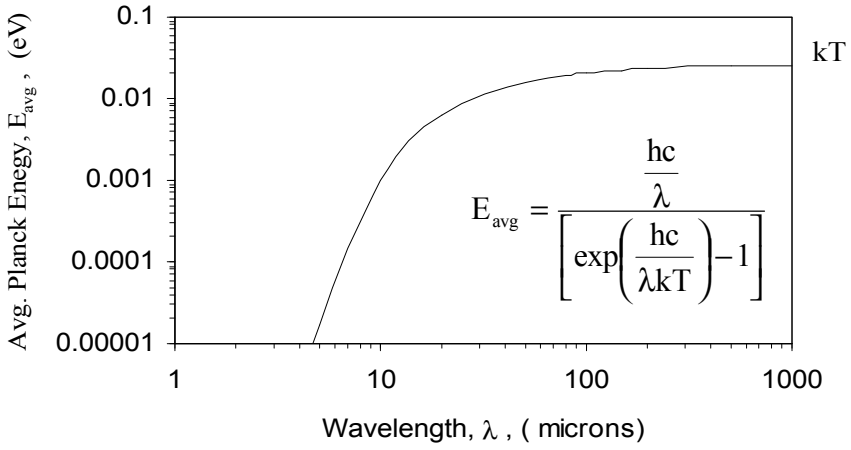

Figure 2 Planck Energy E_{avg} of Harmonic Oscillator at 300 K
In the inset, h and k are Planck's and Boltzmann's constants, and c is the speed of light.

Provided the target radius R is sufficiently large, the IR radiation from the target is not restricted and may be freely emitted or absorbed,

$$\lambda = 4Rn_r > \lambda_{IR} \tag{4}$$

where, $n_r = 1.33$ is the refractive index of heavy water. For $\lambda_{IR} = 100$ microns, R > 18 microns. Conversely, for $\lambda < \lambda_{IR}$ or R < 18 microns, the target restricts both IR emission and absorption. Fig. 2 shows as the target EM resonant wavelength decreases below $\lambda_{IR} \sim 100$ microns, the Planck energy that may reside in the oscillator rapidly decreases. In the limit the Planck energy E_{avg} vanishes as the EM resonant wavelength λ approaches zero,

$$\lim_{\lambda \to 0} \frac{\frac{hc}{\lambda}}{\left[\exp\left(\frac{hc}{\lambda kT}\right) - 1\right]} \to 0 \tag{5}$$

What this means for ICF targets at submicron wavelengths is the allowed thermal kT energy is insignificant, and therefore the laser photon cannot be conserved by thermal absorption. The effect of target temperature prior to IR photon absorption for target EM resonant wavelengths λ is illustrated in Fig. 3. Clearly, the Planck energy E_{avg} at submicron wavelengths depends on the target temperature prior to the IR photon absorption. Since the targets are near ambient temperature at the time of IR photon absorption, the thermal kT energy at 300 K shows an insignificant amount of thermal kT energy is available to conserve the absorbed IR photon. Only if the target is preheated to very high temperatures, say to 5,000 or 50,000 K would the conservation of the absorbed IR photon be one of thermal absorption at submicron EM target resonances.

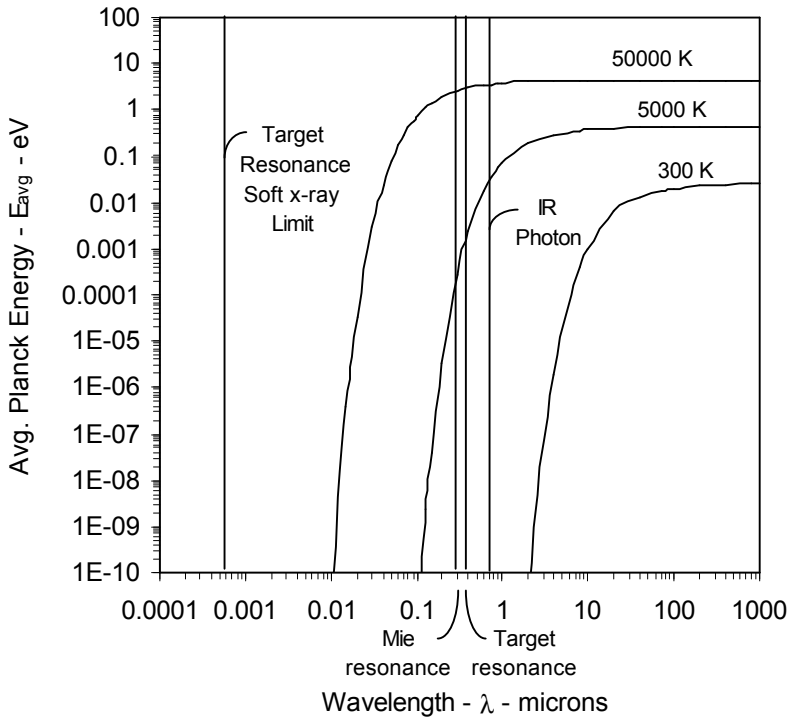

Figure 3 Planck Energy E_{avg} of Harmonic Oscillator at 300, 5000 and 50000 K

Similarly, the Einstein-Hopf relation gives the target specific heat C that quantifies the capacity of the target to conserve the absorbed laser IR photon by an increase in temperature. For a submicron target having mass w, the number n of moles is, n = w/M, where M is the molecular weight of heavy water. Thus, the number N of heavy water target molecules is, $N = nN_A$, where N_A is Avagadro's number. For atoms having 3 degrees of freedom, the total energy U/n is,

$$\frac{U}{n} = \frac{3N}{n}\frac{\frac{hc}{\lambda kT}}{\left[\exp\left(\frac{hc}{\lambda kT}\right)-1\right]} \tag{6}$$

where, the target energy U/n has the units of J/kg-mol. At short λ, $U/n \rightarrow 0$. The well known value of kT occurs at long λ, where $U/n \rightarrow 3N_AkT$.

The specific heat C is defined,

$$C = \frac{\partial(U/n)}{\partial T} \tag{7}$$

In terms of the dimensionless specific heat C*,

$$C^* = \frac{C}{3N_A k} = \frac{\left(\frac{hc}{\lambda kT}\right)^2 \exp\left[\frac{hc}{\lambda kT}\right]}{\left[\exp\left(\frac{hc}{\lambda kT}\right) - 1\right]^2} \tag{8}$$

Fig. 4 gives C* in relation to the submicron target wavelengths of interest. At long λ, $C^* \rightarrow 1$ and at short λ, $C^* \rightarrow 0$. At 300 K, the 150 nm target having a EM resonant wavelength $\lambda_T \sim$ 400 nm, $C^* \sim 0$. Therefore, the target cannot conserve the absorbed laser IR photon by an increase in temperature.

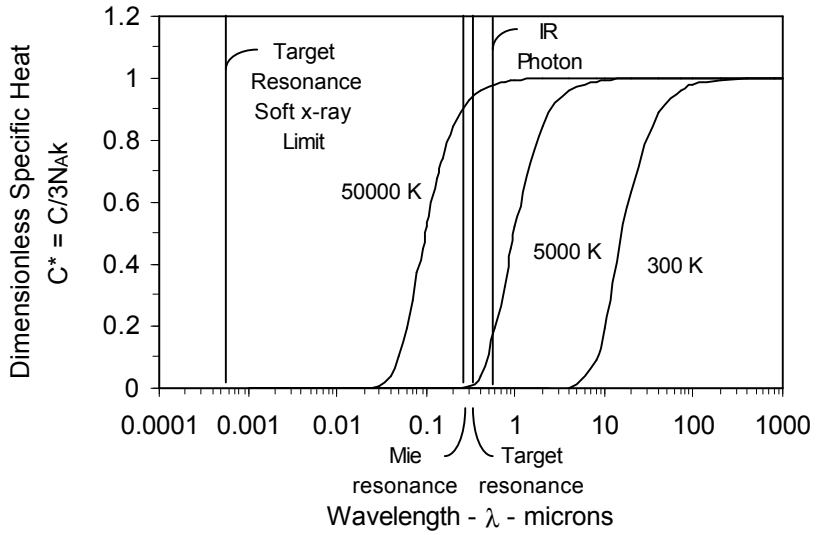

Figure 4 Dimensionless Specific Heat C* at 300, 5000 and 50000 K

In ICF experiments [5] of table top systems, the submicron target is irradiated from one direction. For a flux F of IR photon radiation, the amount of energy U deposited in the target in pulse of τ seconds is,

$$U = \pi R^2 F \tau \tag{9}$$

Numerically, $F \sim 1 \times 10^{19}$ W/cm^2 and $\tau = 35$ fs. For the 150 nm target, $U = 6.19 \times 10^{-5}$ J. However, this is an upper bound. Lower $F \sim 0.5\text{-}80 \times 10^{17}$ W/cm^2 has been reported [7].

The number N of heavy water molecules in the target,

$$N = \frac{4\pi}{3}\left(\frac{R}{\Delta}\right)^3 \tag{10}$$

where, Δ is the cubical spacing between molecules, $\Delta \sim 0.3$ nm.

The IR laser energy U/N_m deposited per molecule is,

$$\frac{U}{N} = \frac{3}{4}\frac{\tau\Delta^3}{R}F \qquad (11)$$

The flux F necessary to initiate fusion for a target radius R for U/N = 6 keV and 6 MeV per heavy water molecule is shown in Fig. 5. For the 150 nm target, U/N ~ 5.9 MeV, or about 3000 – 2keV x-ray photons per heavy water molecule. This is a significant amount of EM energy per molecule, and certainly shows fusion has occurred. However, the flux F could be 3 orders of magnitude smaller and still achieve fusion, say 3 – 2 keV x-ray photons/ molecule. It would appear therefore that the lack of QED confinement has significantly reduced the efficiency of neutron production.

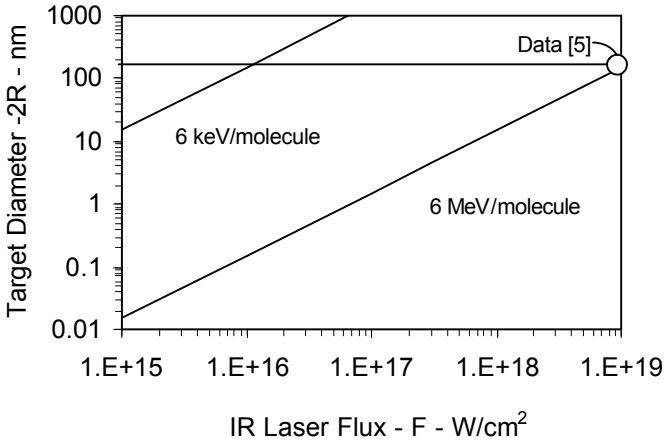

Figure 5 Heavy Water Target Diameters 2R v. IR Laser Flux F

5 EXTENSIONS

The ICF reactor submicron target may be treated as an ambient light source. Indeed, thermal IR photons from the ambient or other light source may be converted into VIS light $h\upsilon_{VIS}$ emission. There are no lasers, only the IR and VIS photons in the ambient surroundings. Many submicron targets are required to produce a commercial light source, say a 100 W light bulb. A single submicron target is depicted in Fig. 6.

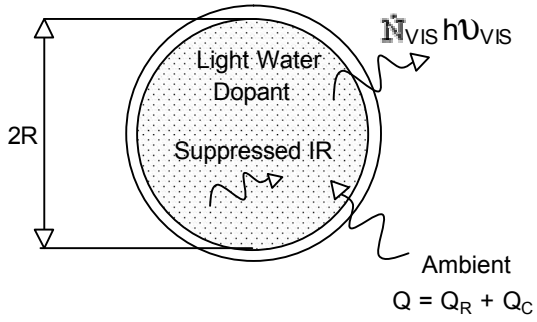

Figure 6 Ambient Light Sources

The total thermal kT energy U of the target having radius R is,

$$U = \frac{4}{3}\pi\left(\frac{R}{\Delta}\right)^3 kT \tag{12}$$

The number N_T of resonant photons having Planck energy E_T is,

$$N_T = \frac{U}{E_T} = \frac{16\pi}{3}\left(\frac{R}{\Delta}\right)^3 \frac{Rn_r}{hc} \tag{13}$$

Suppressed IR within the submicron target means the thermal kT energy of the water and dopant molecules vanishes. Alternatively, the kinetic energy or the velocity of the molecules is brought to zero. Regardless, the temperature of the target molecules remains at ambient temperature and does not drop to absolute zero.

Since the target molecules are at the same temperature as the ambient, it might be thought that heat should not flow into the submicron target. But this is not correct. Heat is transferred to the low kinetic energy target molecules as they collide with the containment shell that is held at ambient temperature, and in effect, heat is transferred from the ambient to the target molecules by collision. The conservation of EM energy gives,

$$\dot{N}_{IR} h\upsilon_{IR} = \dot{N}_{VIS} h\upsilon_{VIS} + mc_P \frac{dT}{dt} \tag{14}$$

where, $\dot{N}_{IR} h\upsilon_{IR}$ is the rate of IR photons into the target, and $\dot{N}_{VIS} h\upsilon_{VIS}$ is the rate of VIS photons emitted from the target, m and c_p are the mass and specific heat of the water and dopant, and dT/dt is the rate of temperature change in the water and dopant. In the terminology of classical heat transfer, the flow of heat Q into the target is,

$$Q = Q_R + Q_C = \sigma A\left(T_o^4 - T^4\right) + h_c A\left(T_o - T\right) \tag{15}$$

where, Q_R is the radiative heat transfer, σ is the Stefan-Boltzmann constant, Q_C is the convective heat transfer, h_c is the convective heat transfer coefficient, A is the surface area of the target; and T_o and T are the temperature of the ambient and the target water and dopant.

Keeping in mind the target molecule temperature T is the same as the ambient T_o except for the fact the kinetic energy of the target molecules is zero, the heat flow Q into the target is computed as though the temperature T of the target molecules is at absolute zero. This is only a matter of convenience in order to compute heat flow as it usually based on temperature differences.

$$\dot{N}_{IR} h\upsilon_{IR} = \left(\sigma T_o^4 + h_c T_o\right) A \tag{16}$$

The target at steady state (dT/dt = 0) gives the power of VIS photons emitted from the suppressed IR within the target,

$$\dot{N}_{VIS} h\upsilon_{VIS} = \dot{N}_{IR} \upsilon_{IR} \tag{17}$$

Numerically, consider a Rhodamine 6G dye that is excited by a resonant target photon at λ = 510 nm having Planck energy E = 2.4 eV. For water, n_r = 1.33 and the target diameter 2R = 191.7 nm having an area $A = 4\pi R^2 = 1.15 \times 10^{-13}$ m^2. In ambient air, h_c = 7 W/ m^2 K and for T_o = 300 and T = 0, Q_R = 52.8 pW and Q_C = 242 pW. Thus, Q = 294.8 pW. For Rhodamine 6G [14], $\eta \sim 1$, and VIS photons produced $\dot{N}_{VIS} h\upsilon_{VIS}$ = 294.8 pW and $\dot{N}_{VIS} = 7.7 \times 10^8$ s^{-1}. The total thermal kT energy in the target is, U = 3.52 MeV and the number N_T of resonant target photons having Planck energy E_T = 3.11 eV is, $N_T = 1.13 \times 10^6$.

In general, dopant other than Rhodamine B may be added to the light water, e.g., Luminol [15]. Each dopant having a specific excitation wavelength requires a reasonably accurate corresponding target diameter. Fig. 7 gives the submicron target diameters 2R for the Planck energy E_T of various dopant assuming a refractive index $n_r = 1.33$.

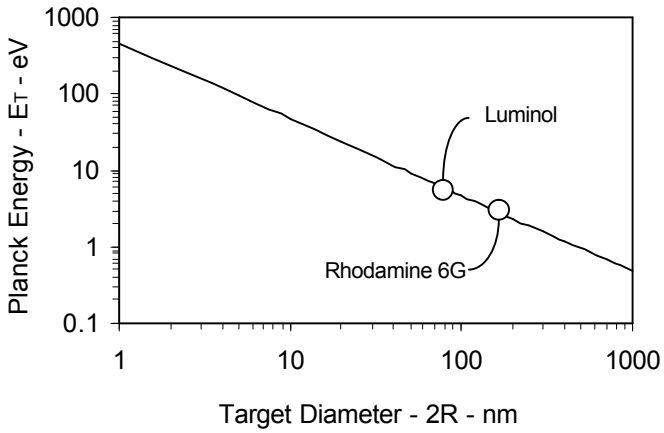

Figure 7 Ambient Light – Target Excitation Energy v Diameter 2R

Typical applications of the ambient light source are illustrated in Fig. 8.The compact light utilizes uses $3.4x10^{11}$ – 294.8 pW ambient lights arranged in a 2 mm diameter sphere to produce a 100 W light bulb. In a conventional light bulb, the IR waste heat loss can be converted to VIS light by coating the bulb surface with the ambient light source.

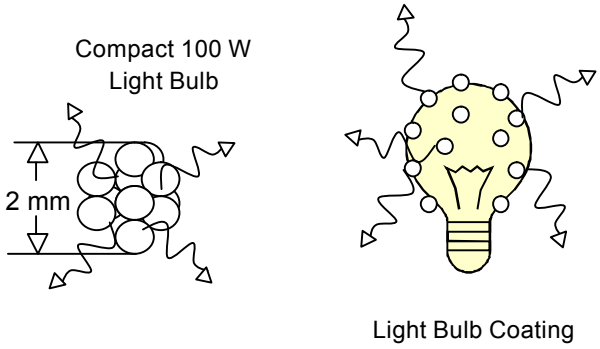

Figure 8 Ambient Light - Applications

Other applications may be readily apparent to the reader. However, a comparison of the compact light bulb and the light bulb coating suggests the most likely ambient light applications are light sources that recover waste heat from hot surf aces, e.g., combustion engines. Since waste heat temperatures are generally higher than ambient, the increase in light power is expected to significantly reduce the number of ambient light sources from that described here for the limiting case of extracting heat from the ambient.

6 CONCLUSIONS

Since the late 1990's, the ICF research with submicron targets using compact intense milli-joule femtosecond IR lasers is a significant accomplishment in relation to the prior art of large-scale mega-joule lasers with pea-sized targets. This paper does not offer any new experimental findings to those presented in the open literature. Rather, this paper proposes that the advances in ICF research occurred using submicron targets might be explained by QED confinement of the laser IR photon that does not occur in the pea-sized targets.

- The Mie theory requires the laser IR photons to be fully absorbed by the submicron target. However, the pea-sized targets are larger than the wavelength of the laser IR photon, and therefore only absorb a fraction of the laser IR radiation.

- Submicron targets having high EM resonances beyond the VIS require the specific heat to vanish, and therefore the absorbed IR photon cannot be conserved by an increase in temperature. Instead, the absorbed laser IR photon undergoes frequency up-conversion to the EM resonant frequency of the target prior to conserving the absorbed IR photon by ionization, fusion, and x-ray emission.

- Pea-sized targets have low EM resonances beyond the IR that allow finite specific heat, and therefore the absorbed laser IR photon is conserved by an increase in temperature.

- In submicron targets, the QED confinement of successive absorbed laser IR photons cumulatively increases the EM energy without bound, reaching a few MeV per heavy water molecule. With pea-sized targets, the temperature is required to increase to a few millions of degrees, a far more difficult if not impossible task.

- Encapsulating the submicron target in a containment shell is expected to significantly improve the neutron yield from the 1 bar atmospheric pressure in heavy water spray experiments. A 10 nm thick silicon carbide shell on a 150 nm target enables the Coulomb pressure to reach 7000 bar prior to fracture.

- The containment shell reduces the 6 MeV EM energy now absorbed per heavy water molecule to 6 keV and still initiate fusion.

Although ICF reactors with submicron targets is a significant advancement over the prior art, any improvement in neutron yield by QED confinement may be inconsequential because the important economic issues of the cost of the submicron targets and disposal of containment shells remain to be resolved. Because of this, extensions to this paper consider more immediate applications of the ICF submicron targets, specifically providing artificial lighting that does not require electricity.

- By replacing the heavy water with light water doped with light sensitive Luminol or Rhodamine 6G, a large number of submicron targets may be configured into compact VIS light sources that operate solely from the thermal energy in the ambient environment, or by enhancing the artificial light from conventional sources.

Funding of ICF research directed to the use of submicron targets as ambient light sources is requested. Author can be reached at http://www.geocities.com/thomas_prevenslik

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