REASONS FOR THE q VALUES IN A-55

At the time when A-55 was written, there was a consensus of opinion based
on various measurements on homogeneous and heterogeneous water-uranium systems
that such systems may have *at room temperature* a multiplication factor which comes very close to 1
but will not exceed 1 by more than a minute fraction, if at all. This opinion
was based on much better evidence than there was available for any individual
constant, for example, μ. If we now replaced, as the slowing agent, hydrogen
by carbon by substituting 25 to 30 carbon atoms for one hydrogen atom, one
should expect a system in which the loss of neutrons due to uranium resonance is
about equal to the loss due to resonance in the hydrogeneous system. Taking
at room temperature the absorption cross section of carbon at .005, 25 to 30 carbon
atoms would, at room temperature, have an absorption of only about .13 to .15,
whereas, the thermal absorption cross section of hydrogen atom is about .3.
Accordingly, one has to expect that the uranium-graphite system is more favorable
and will have, in the most favorable case, a multiplication factor above 1, but
cannot have, at room temperature, a multiplication factor very much above 1, unless
the carbon cross section should be considerably lower than .005.

The set of constants used in A 55 was
so adjusted that the formulae given
in A 55 yield for room temperature
in the most favourable case for
$\sigma_c(C) = 0.005$ a multiplication factor
of slightly above one ($\eta^4 f k \approx 1.125$
with $kp = 1.87$ $i\gamma = 0.6$
$\eta^4 f k = 1.125$ $= 0.6$)

The same set of constants give
then if put into the formulae
for room temperature as the
most favourable size for 15 gm/cc
density by a radius slightly above
$\sqrt{cm}$ and for the most favourable

weight ratio of uranium to carbon
a value which is close to the
optimum and for which in the
light of our present knowledge
the multiplication factor he in fact
above 1 exist —

Please note that from the
consideration given above it would
follow that if the carbon cross
section were 0.01 the carbon
would just about be equivalent
to hydrogen. In my
letter to Fermi (which dealt with
heterogeneous mixtures but did
not yet envisage the use of thick
layers of graphite) I If the cross section
were 0.01 carbon would be no
better than hydrogen" On July
5th 1939 envisaging the use of thick
layers of C between uranium
containing elements I wrote to Fermi:

Nr. 3

this consideration gives carbon
a sufficient advantage going sufficiently

beyond the equivalent considerations
obtained in the letter of July 3rd to
enable me to state in A 55 that
that the chain reaction in the
U – carbon lattice would go
even if the carbon absorption were
0·01 but the advantage was
not sufficient to make this
statement hold for room
temp. For high temp where
the optimum is shifted towards
larger uranium spheres and thicker
layers of carbon between
the uranium spheres this
advantage of carbon becomes
greater and A 55 says that it becomes
sufficiently great to raise the
multiplication factor above one
even for the carbon cross section
were as high as 0·01. —